PB-223 568

# A SURVEY OF EMISSIONS AND CONTROLS FOR HAZARDOUS AND OTHER POLLUTANTS

A. J. Goldberg

Environmental Protection Agency
Washington, D. C.

February 1973

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PB 223 568

EPA-R4-73-021
FEBRUARY 1973

Environmental Monitoring Series

# A Survey of Emissions and Controls for Hazardous and Other Pollutants

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INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

Office of Research and Monitoring
U.S. Environmental Protection Agency
Washington, D.C. 20460

185

**BIBLIOGRAPHIC DATA SHEET**

1. Report No. EPA-R4-73-021

2.

3. Recipient's Accession No. PB-223 568

4. Title and Subtitle

A Survey of Emissions and Controls for Hazardous and Other Pollutants

5. Report Date February 1973

6.

7. Author(s) Dr. A. J. Goldberg

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

ENVIRONMENTAL PROTECTION AGENCY
Air Pollution Technology Branch
Office of Research & Monitoring
Washington, D. C. 20460

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

Same

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

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17. Key Words and Document Analysis. 17a. Descriptors

Air pollution
Air pollution control equipment
Exhaust emissions
Industrial wastes
Food industry
Chemical industry
Metal industry
Paper industry
Textile industry
Cements

Arsenic
Asbestos
Barium
Beryllium
Boron
Cadmium
Chlorine
Chromium
Copper
Fluorides

Lead
Manganese
Mercury
Nickel
Organic compounds
Selenium
Tin
Vanadium
Zinc
Particles

Odors

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 13B

18. Availability Statement

Unlimited

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 175/185

22. Price 11.25/1.45

FORM NTIS-35 (REV. 3-72)

THIS FORM MAY BE REPRODUCED

USCOMM-DC 14952-P72

# A SURVEY OF EMISSIONS AND CONTROLS FOR HAZARDOUS AND OTHER POLLUTANTS

by

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## ABSTRACT

A preliminary analysis was undertaken to prepare a control technology development plan for air pollution problems facing industry. A literature search was completed (with 144 references) to estimate toxicity levels of 18 pollutants, and the magnitude of emissions from industrial emitter types or classes of emitting processes. A review of control methods organized by pollutants as well as industry, offensive trades (animal processing), food industry (brewery and cannery), chemical industry (paint and rubber), metal industry (foundry and metal coating), other (paper textile, cement, etc.) is included.

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# ACKNOWLEDGMENT

This report was prepared by the Office of Research and Monitoring, Environmental Protection Agency, but the contents incorporate much information provided from research contractors and grantees. Two firms which contributed significantly to this survey are: The Mitre Corporation, EPA contract 68-01-0438, and Midwest Research Institute, EPA grant 801615.

# I. INTRODUCTION

Considerable evidence has accumulated to prove that trace metals and other particulate or gaseous substances present in air are a threat to human health when ingested in sufficient quantities. These substances are continually being added to the atmosphere by industrial operations primarily from combustion sources and from the metals industries and secondarily from the production of chemicals, ceramics and miscellaneous manufactured end products.

Efforts are now being expended to define the specific hazards posed by these emissions. Thus far, three materials have been designated hazardous in accordance with Section 112 of the Clean Air Act of 1970 as amended. Another 15 substances have been designated pollutant candidates by the Administrator of EPA for which control strategies are to be determined by the end of FY 1974 and standards promulgated as soon thereafter as feasible.

As the hazardous pollutant problem comes more clearly into focus its seriousness becomes more evident and its dimensions loom larger. In particular the dangers associated with long term low level exposure to specific pollutants, for example cadmium and other trace metals as well as polynuclear organic material are just beginning to be recognized and defined. Among the specific consequences of this exposure are increased incidences of disease and reduced life spans in the general population.

It is probable that a number of pollutants are or may come to be generally present in the atmosphere at sufficient levels to constitute a serious hazard. The dangers associated with these pollutants is compounded because a major fraction of these materials is emitted in gaseous or fine particulate form which escape the normally used collection devices, and which also penetrate the natural filters of the respiratory tract to reach the air spaces of the lung. Moreover, submicron particles are more heavily deposited in the lungs, the efficiency of deposition approaching 100% as particulate size decreases. Even those particles that have settled out of the atmosphere remain of great concern because of their ability to contaminate food and water.

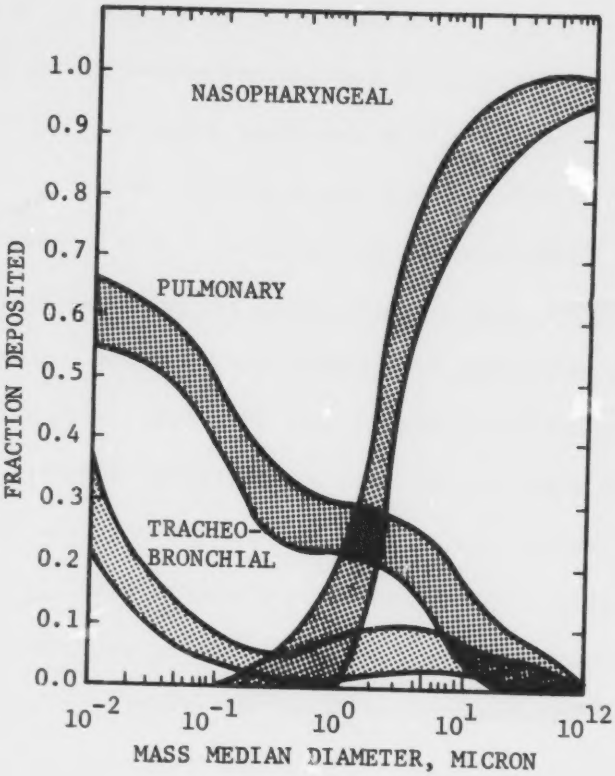
The toxic effects of short and long term increase in body burdens which can be quite severe is reported widely in the literature. Although quantitative information pointing to specific control objectives is still being developed, the ultimate need for control is clear. Our objective is to insure that the technology is available to guarantee that control.

The difficulty of the control problem for hazardous pollutants is compounded because the degree of toxicity is generally not proportional to the mass of emissions. Quite possibly very small amounts of material can have severe effects on human health, not only because these substances are more potent but because they persist in the atmosphere, are more easily respirable and more readily retained, in the lungs.

Indications of this are shown in Figures 1 and 2. Figure 1 shows a substantial increase in the fraction of particles deposited in the pulmonary and tracheobronchial systems of the respiratory system. The retention of particulate matter in the lung (Figure 2) increases as particle size decreases above the 1.0 micron level at which point there is a maximum retention rate over 75%. More than half of all particles in the range of 0.5 to 2.0 microns will be retained while only a small amount of those particles less than .25 microns or more than 3.0 microns are retained. (It should be noted that there has been considerable work done using a variety of methods to generate the date on fractional deposition of particles. See for example Chapter 9 of Air Quality Criteria for Particulate Matter, NAPCA January 1969 and references cited.)

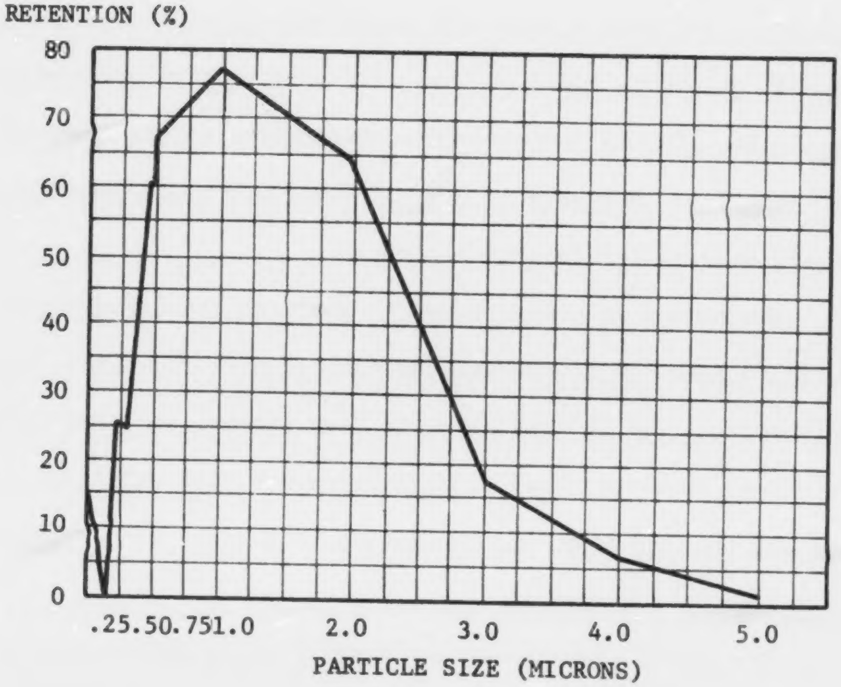
Fine particulates can modify weather patterns by acting as nuclei for condensation or freezing. They absorb and scatter light and decrease visibility. Visibility reduction is caused primarily by the 0.1 to 1.0μ radius particles which appear in the atmosphere. Fine particles may also interfere with solar radiation and can cause changes in the heat balance of the earth-atmosphere system. Here too, small changes associated with increasing particle loads may well have disproportionate long term meterological effects.

Considering these issues and the extent of documentation of the toxic and otherwise injurious nature of most of these substances, about which more will be said below, it seems incumbent upon EPA to



*DATA FROM NAPCA - AIR QUALITY CRITERIA FOR PARTICULATE MATTER, p. 115.

FIGURE 1*
FRACTION OF PARTICLES DEPOSITED IN THE THREE RESPIRATORY TRACT COMPARTMENTS AS A FUNCTION OF PARTICLE DIAMETER



*REFERENCE 34, p. 23 (AND REFERENCES CITED).

**FIGURE 2**
**RETENTION OF PARTICULATE MATTER IN LUNG IN RELATION TO PARTICLE SIZE***

be as precise as possible in establishing quantitative standards for ambient air quality and/or emission levels. However, a number of prerequisites exist before this can be done. The first requirement is to specify maximum safe ambient air concentration of each pollutant and then compare the anticipated control measures required to meet standards based on this data with control systems in use or available. On the basis of this comparison, we can identify gaps in technology necessary to control hazardous pollutants and prepare an R&D program for this technology.

The effort is now underway to generate the information upon which to make the aforementioned comparisons. The first stage of this activity is to determine the distribution and magnitude of emissions from the chief pollutant sources, the extent of control in use and the degree to which existing technology can be implemented to improve the controls.

The second step toward preparation of an R&D program is to specify the degree to which certain emission sources must be controlled. This requires first that we establish values of ambient air quality to be regarded as probable goals of a control strategy and that we relate emission levels from each candidate source to the target air quality level. Having accomplished this, we can then proceed to the third step in the R&D problem definition process which is to state the specific technological achievements necessary to devise a control system that will restrict emissions to the levels stipulated as maximal if the air quality targets are to be reached. Based on this problem definition we can outline a program to develop necessary technology.

This report reviews the work done to date in implementing these three preliminary steps, and delineates the effort yet needed. Thus far, the bulk of our efforts have been devoted to the first stage of analysis. This has generated data about the magnitude of emissions as well as some limited chemical and physical data and information concerning controls. This work is summarized in Section II of this report. Consideration of steps two and three of the problem definition effort are given in Section III. Also included is a brief overview of available control technology. All major types and subtypes of control device are tabulated along with an indication of the processes in which they are found and their range of efficacy. Problems associated with control of hydrocarbons and odors are addressed briefly in Section IV. Further problem definition work is planned for each of these two subjects.

Four appendices are included which contain some background material. Appendix A tabulates emissions for each pollutant. Appendix B contains a discussion of the hazards associated with several pollutants for which NAS or other surveys have been published. Appendices C and D include material flow charts through the economy and process flow charts respectively.

## II. SCOPE AND MAGNITUDE OF EMISSIONS OF POLLUTANTS

The first phase of analysis was to determine how much of each pollutant was being emitted to the atmosphere and how these emissions were distributed each among the principal industrial sources. Information was collected from the literature for each of the following 18 pollutants showing the emissions by weight from over 200 industries.

- arsenic
- asbestos
- barium
- beryllium
- boron
- cadmium
- chlorine
- copper
- fluorides
- lead
- manganese
- mercury
- nickel
- POM
- selenium
- tin
- vanadium
- zinc

The major types of control devices in use in each of these industries were listed as well as the percent application and average efficiencies of the controls. This information is summarized in Table 1 and reordered by pollutant and tabulated in Appendix A.

A word of caution needs to be introduced here concerning the numbers appearing in all the tables of this report. Although these represent the best data from the literature sources cited in Table 1 the data are approximate at best, not only because completeness is impossible in most cases, but because measurement techniques may be deficient and because conditions are constantly changing. Nevertheless, the results are adequate to identify key sources of potentially hazardous pollutants and to establish the relative importance of certain industries.

We must also emphasize that total amount of emissions is neither the sole nor necessarily the chief criterion to be used in selecting problems for further attention. A prime consideration is the toxicity of the material emitted in a typical location, which depends not only on the number and sizes of the sources in a given locality, but also the local topography and meteorological conditions and the physical layout of the source. We plan to deal with these factors case by case as is necessary in a manner to be described more fully below.

The number of people affected by a source or group of sources also bears on the question of R&D strategy. It appears that in many instances pollution sources are situated near to significant populations. Each case needs to be looked at separately to determine whether it is an exception to this.

On the basis of the information on magnitude of emissions in Table 1, certain points are evident. Mining and materials handling processes are generally uncontrolled or minimally controlled with few exceptions as are most combustion sources. Both of these categories can yield a variety of pollutant materials in relatively large quantities. So called "consumptive processes" represented in the Table also tend to be relatively uncontrolled, although with the exception of pesticide, herbicide and fungicide use, the emissions appear to be relatively negligible. The application and efficiency of controls in the primary and secondary metals industries is substantially greater, with the exception of the materials handling steps, although this varies substantially from case to case.

To generate a clearer perception of the emission problem, we found the magnitude of emissions from each of the specific emitting sources within the industrial processes. This information is presented in Table 2, where pollutant sources are ordered by weight of emission. The tonnages shown represent the total emissions of all the potentially hazardous materials considered for Table 1. Emissions from open hearth furnaces head the list of industrial sources although these are far less than those created by open burning. In general, emissions from processes within the ferrous and non-ferrous metal industries appear high up on the list, as do boilers and burners of all types used in power plants and elsewhere.

Grouping the various sources of emissions into broader categories of emission sources. A short list of the major polluting industries is included below.

## Principal Polluting Industries

| Industry | Emissions | Principal Pollutants |
|---|---|---|
| Iron and Steel | 103,822 | Ba, Cd, Cu, Pb, Mg, Sn, V, Zn, Fluorides |
| Non-Ferrous Smelting | 68,002 | As, Cd, Cu, Fluorides, Pb, Mg, Hg, Se, Zn |
| Industrial Power and Heat Generation | 127,839 | As, Ba, Be, B, Cd, Cr, Cu, Fluorides, Pb, Mg, Hg, Ni, POM, Se, Sn, Va, Zn |
| Residential Power and Heat | 121,714 | As, Ba, Be, B, Cr, Cu, Fluorides, Pb, Mg, Hg, Ni, POM, Se, Sn, Va, Zn |
| Chlorine Production and related mfg | 56,370 | Cl, Hg |
| Metallurgical Coking | 43,380 | POM |
| Incineration | 34,307 | B, Cd, Cu, Fluorides, Mg, Hg, POM, Se, Zn |
| Phosphate and related fluoride emitting industries | 13,330 | Fluorides |

The Tables 1 and 2 in the Appendix present this information in a more detailed form.

In addition to the data on weight of emissions shown in Table 2, other factors exist which influence our ultimate choices of operations for detailed analysis. We should also take into account the nature of the population exposed to emissions, the mix of pollutants involved and their physical and chemical characteristics. Table 3 summarizes some of this information for those operations contributing 90% of the estimated total of hazardous pollutant emissions. The Table presents a breakdown of emissions by source for each industry, the number of sources in each category, the total population in those communities closest to the sources and the basic nature of the pollutants in each case. Although the data on population affected is incomplete, to the extent that it is available and represented in Table 3, it may provide us with some additional direction in choosing among alternatives.

The last two columns in Table 3 point to an important issue in control development. This is that in many instances a source will emit a variety of pollutants in several forms. For example, blast furnaces in iron and steel production emit varying amounts of seven trace metals, fluorides and polynuclear organic material. The emissions are comprised of gases and both gross and fine particulates. The rated efficiency of all the control devices in use depends in varying degrees on the particle size distribution of the emitted stream, because, as is well known most available control devices are very inefficient in collecting fine particulates, i.e., those smaller than 3 microns in diameter.

The extent to which the hazardous pollutant problem is a fine pollutant problem can be seen from Table 4 which gives a breakdown of the fraction by weight of pollutants in each particle size range emitted by the largest pollution sources. A point to be noted here is that these measured particle size distributions will differ from the in situ particle distribution. The difference depends on the history of the pollutant stream between measurement and release and on the measurement technique, both of which may promote agglomeration resulting in changes in size distribution. Even so, in many cases the fine particulates are a major mass fraction of the materials which have escaped collection.

It should be reemphasized at this point that the hazards posed by toxic trace materials in fine particulate form can be disproportionate to the mass involved. As mentioned at the outset the persistence of fine particulates in the atmosphere, their effect on visibility and meteorology, their ability to penetrate the natural barriers of the respiratory system to enter deep into the lungs and their rate of retentivity all contribute to the hazardous character of fine particulates.

The relative importance of the fine particulate fraction increases if one considers the hypothetical situation in which the best available controls are applied to all sources. A computation was made to reflect this situation in order to determine the extent of the residual emissions problem assuming that the best control technology were implemented everywhere. The results of this computation are shown in Table 5. We note first that although there is some reduction in the total emissions, a large portion of the problem remains, following 100% application of the best known control technology. For example, estimated emissions of about 50,000 tons/year from pulverized coal boilers would be reduced to 20,000 tons/year if best available technology were universally applied.

It should be remarked, however, that the values presented are based on the assumption that the device which now gives the best results, i.e. lowest emissions, can be applied with equal effectiveness to all sources. While this is generally not the case because sources may vary considerably, nevertheless, the numbers generated in this way offer us some insight into the approximate level of control achievable. Thus, if no reduction in the level of emissions can be made, this is indicated in Table 5, in a column showing the mass emissions expected assuming that the best available controls are used.

In those cases where some best control technique can be identified, and where a reduction in the mass of emissions is indicated the bulk of the improvement is in the large particulate fraction. The last column of Table 5 shows that generally after the application of best controls a large fraction of the emissions is in the form of fine particulates. In several cases this amounts to large tonnages in absolute terms, which is more significant in view of the fact that fine particulates may be dangerous even in lesser amounts.

To calculate the estimated emissions for fine particulates shown in Table 5, it was assumed that the percent of fine particulate emissions represented in the fourth column remained unchanged. It should be noted that here the principal purpose served is to highlight the key problems rather than to assign immutable numbers to a situation.

The processes that would be most greatly impacted by universal application of the best control devices now in use are open hearth furnaces in the iron and steel industry, blast furnaces used in the secondary lead, secondary copper and non-ferroalloy industries, sintering operations for primary metals and incineration. In each of these cases, the total emissions would be very greatly reduced if the best control technology were applied. However, as already indicated large numbers of fine particulates would continue to be emitted.

It appears that on the basis of the foregoing discussion, the major emitters of hazardous pollutants can be grouped as follows.

1. Processes whose mass emissions will be somewhat reduced if the best control devices are universally employed, but for which a residual fine particulate problem would remain.

   open hearth furnaces - iron and steel
   municipal incinerators
   sintering furnaces - iron and steel, primary zinc
   iron ore pellet plants
   blast furnaces - secondary lead, secondary copper,
   non-ferroalloys

2. Processes whose residual emissions after application of best conventional technology are principally fine particulates (less than 5 micron size) (i.e. more than 75%).

   Pulverized coal boilers
   sintering - primary zinc, primary lead
   asphalt blowing
   natural gas combustion
   oil burners - power plants, industrial

blast furnace - primary lead, ferroalloys (also
secondary lead & copper)

3. Processes whose emissions are not principally fine particulates but which are significant in spite of 100% application of best control.
    - roasting - primary copper, primary zinc
    - asbestos ore mining and handling
    - blast furnaces - iron and steel industry
    - ore mining and handling - general
4. Particulate emitting processes which are not controlled.
    - open burning
    - residential and commercial oil burners
    - metallurgical coke
    - oil burners - power plants and industrial
5. Processes whose particulate emission distribution is unknown.
    - Open burning
    - ore mining and handling
    - oil burner operation
    - domestic incineration
6. Processes with gaseous emissions.
    - chlorine liquefaction
    - bleaching - pulp and paper

In view of the different situations represented above we will have to consider R&D work along a number of different lines in order to deal with each of the varied groups of processes. The need to deal with the general fine particulate problem is clear. It will be necessary to identify and overcome those technological obstacles which may exist to mar the compatibility of existing processes and existing best technology. In some cases, best available control is not adequate even excluding the problems associated with collecting fine particulates, and in others no controls at all are in use either because of economic or technological reasons. In still others, the problems are undefinable because data are absent.

Having thus classified the principal emission sources, we can then proceed to deal with each in a more definable framework. However, a key detail necessary to guide our enterprise is a definition of the degree of control which is essential. This need must be carefully defined in terms of what is required to safeguard health and welfare.

## III. DEFINING CONTROL SYSTEM NEEDS

If we are to anticipate the needs for control technology, we must first clarify the goals which are to be met in terms of pollutant air concentration levels. Specifically, it is necessary to know the maximum or most probable safe ambient air quality levels of each pollutant, and the probable acceptable level of each as the basis on which emission standards can be proposed.

In spite of the vast literature dealing with toxic effects, there now exists no good quantitative data concerning safe ambient air concentrations. At present, the Health Effects Division is conducting studies to pinpoint hazard levels for a variety of pollutants. To assist in this, the National Academy of Sciences is issuing a series of documents dealing with biological effects of airborne pollutants. Some of the key conclusions of those documents which have already been released are mentioned below in Appendix B. Basically, however, nothing in these documents points specifically to maximum acceptable ambient concentrations or emission levels. Moreover, the conclusions of the Health Effects Group will not be forthcoming in time to use them as a basis for FY 1974 Control Technology R&D program planning. In some instances, it may take considerably more time to reach agreement on specific figures.

Accordingly, it is necessary for us to somehow anticipate these figures. That is to say we must establish probable ambient air quality values or ranges of values to guide our programming efforts.

We have asked the Health Effects Division to provide us with estimates of ambient air quality levels representing the most stringent, the least stringent, and the most probable standards that are likely to be set to determine alternative strategies for R&D. The Health Effects Division has responded that no information of this type is available or is likely to be in the near future. In the absence of any inputs from within EPA, we are soliciting opinions on these matters from outside consultants. This will enable us to estimate levels of ambient air concentration which may constitute a hazard and prepare R&D strategies to develop the controls needed to satisfy anticipated standards.

More than 20 individuals in medical centers, research laboratories and universities around the country have been contacted.* Some of the responses are given in Table 14 along with comparable data for specific substances measured at selected locations. (See refs. cited Table 14). Additional responses are anticipated from individuals solicited in the survey after they have had time to review the questions put to them. It is also planned to circulate the responses among the individuals solicited to generate comment and additional feedback.

Identifying desirable ambient air quality levels does not in itself define control requirements. To do so requires that emission levels be found which will not cause the desired ambient concentrations to be exceeded. There is only one sure way to relate emissions to ambient air quality levels and that is via a controlled experiment in which cooperation is guaranteed not only from all sources that may affect air quality in a region but also from the environment. Lacking these rather rare circumstances we can make use of emission dispersion models, which if properly calibrated can give reasonable estimates of the ground level concentrations resulting from specified rates of emissions.

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*See MITRE Corporation Working Paper 10144 prepared under Contract No. 68-01-0438.

We propose to utilize these models in establishing emission level targets for the sources in our study. To gain some quick insights into the problem, we will treat an individual source emitting against a fixed background of pollution created by all other major sources in a region. In this way, we can define chosen ambient standards, and thereby obtain estimates of the extent of control deficiencies.

This work is underway. As of this writing one model study is completed for the U.S. non-ferrous smelting industry. The results of this and subsequent studies for other industries are to be compiled in a separate report. Some of the initial results of the work are presented in Figure 3 to illustrate our approach. In Figure 3 are plotted average values for the maximum ambient concentration of selected pollutants at a distance from the source, as a function of emissions from that source. Parameters of the calculation include stack height, wind conditions and particle size distribution. Although

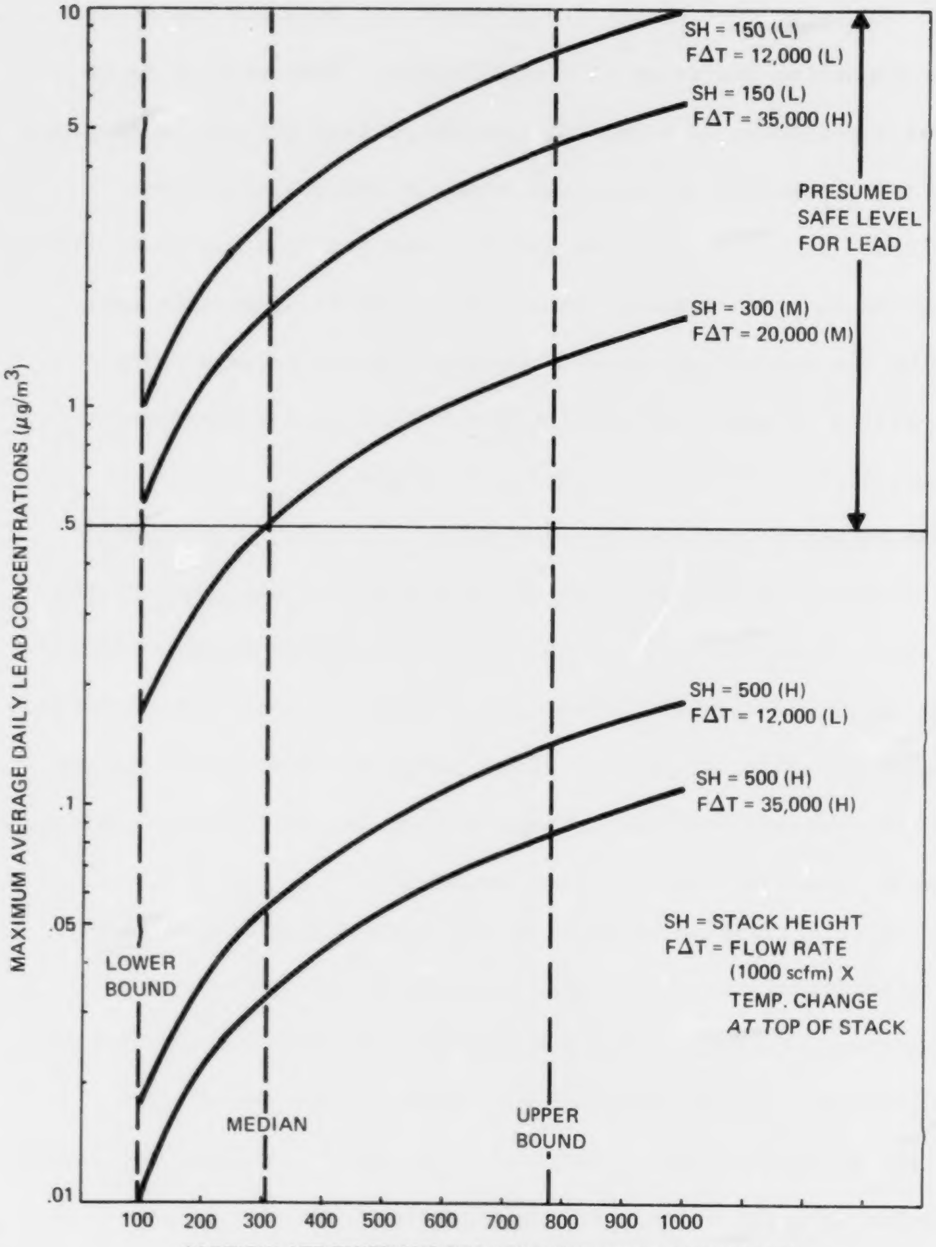

FIGURE 3

COMPARISON OF PRESUMED SAFE AND AMBIENT AIR CONCENTRATIONS OF POLLUTANTS FROM SELECTED SOURCES (LEAD SMELTERS) information is available which permits us to treat each of the smelters in this county we have chosen to represent the data for the generic case encompassing the range of possibilities. This permits us to abstract a statement of a generic problem calling for the development of control capability to treat the toughest and most prevelant conditions. In addition to the ambient concentration curves in Figure 3 we show the range of ambient values identified as acceptable upper limits by the toxicology experts consulted in our surveys. The juxtaposition of these two sets of data offers us the opportunity to discern probable needs and to plan accordingly.

Having defined in some way the extent of controls desired in terms of limits on the magnitude of emissions, we then confront the issue which bears directly on the nature of the R&D program, namely, to what extent is current technology inadequate to the task of meeting the needs for emission control? Some background information on the subject of available control systems and the extent to which they might be used in specific cases has been assembled.

Table 7 gives an overview of the frequency with which the major pollutant collector types are used in each of some major industries. In Table 8-A and 8-B, some additional information is presented for various types of wet scrubbers and centrifugal collectors respectively. Over twenty types of scrubbers are listed together with the principal industries in which each is used. On balance scrubbers show higher efficiencies of collection, than centrifugal systems more so for the lower size ranges.

The usual range of particle sizes effectively removed by scrubbers, however, is greater than 2 microns. The exception to this generality is the venturi scrubber which is somewhat more efficient than other types of scrubbers in the fine particulate range. Additional data of this type is being assembled to complete this survey.

More detailed information on the efficacy of control devices is presented in Table 9. Data are shown relating to the collection characteristics of a particular device as it applies to the principal pollutant emitted from a specific source within a specific process. The best estimates of particle size range involved, dust loading and efficiencies, are also shown. In each case general efficiencies are also compared with fine particle collection efficiencies which are invariably lower, a fact which again illustrates the need for more effort in this area.

Requirements for additional R&D are also highlighted by those cases listed in Table 5 where deficiencies in best available control are called out, or where no effective controls are in use. Those sources which fit either of the above circumstances and which contribute to ambient conditions exceeding projected safe levels are prime subjects for control technology development.

## IV. OTHER POLLUTANT PROBLEMS

### A. Hydrocarbons

Hydrocarbon control is a difficult problem because the emission potential for hydrocarbons pervades industry. Even the sub-class of polycyclic organic matter may be emitted from nearly all industrial processes. The latter is of great importance in view of the recently published findings of the National Research Council[140] showing strong statistical evidence linking benzo-pyrenes with rising rates of lung cancer. Other hydrocarbons generally undergo atmospheric reactions to form compounds responsible for vegetation damage, eye irritation and visibility reducing aerosols.

The total estimated national emissions of hydrocarbons in 1969 were 37,400,000 tons.[141] Although some controls are reported for petroleum refineries and storage of petroleum products, little if any control is otherwise exercised. Some of the more important sources of hydrocarbon emissions are as follows: *

Hydrocarbon Emissions

- Petroleum refining
- Gasoline distribution and marketing
- Chemical manufacturing
- Coal coking

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* More quantitative information is available concerning hydrocarbon pollutants, which is being organized in a separate report.

  - Fuel Burning
  - Waste disposal
  - Food processing
- Organic Solvent Emissions
  - Manufacture and application of protective coatings
  - Rubber and plastics
  - Degreasing and cleaning
  - Dry cleaning
  - Printing

Some of the generally available methods of control are:

1. Petroleum Refining
   - Floating roof tanks
   - Vapor recovery facilities
   - Covered waste treatment plants
   - Condensation of emissions
   - Flaring of purge line
   - Good operation and housekeeping
2. Chemical Plants
   - Flame and catalytic afterburning
3. Coal and other Fuel Burning
   - Hydrocarbon collection
   - Good maintenance and good combusting

4. Waste Disposal

   Good incineration procedures

   Sanitary landfill

5. Food Processing

   Scrubbers

   Condensers

   Afterburners

6. Organic Solvent Emissions

   Incineration

   Absorption processes

   Condensation

Further definition of the nature of the emission problems is necessary including identification of specific sources, the magnitude of emissions in each case and the gaps in available control.

A class of hydrocarbon emissions of major concern are the organic carcinogens which fall into three main categories, polynuclear aromatic hydrocarbons, polynuclear heterocyclic and oxygenated compounds and alkylating agents. A number of these have been shown to increase tumor incidence in animals. A recent NAS study has reported a statistical correlation between benzo (a) pyrene concentrations in the atmosphere and incidence of lung cancer in humans.

The polynuclear organic materials are found in the atmosphere primarily as compounds absorbed on soot particles. Their biological effects are strongly dependent on physical characteristics of the particles, notably the particle size which determines the extent of penetration into the lungs. Particles smaller than 2.5 microns penetrate the normal barriers and are retained in the lung. Percentage retention as a function of particle size is shown in Figure 2. Hydrocarbons are eluted from soot particles which have deposited on the skin or entered into the respiratory tract and the rate of elution is also strongly dependent on particle size. In addition to carcinogens, other organic compounds are emitted into the air which act as irritants to facilitate the activity of carcinogens.

The major stationary emission sources of polynuclear aromatics are combustion processes including burning of coal, oil, gas and refuse; and industrial processes. A survey of heat generating sources ranging from residential heaters to heavy industrial power boilers has been conducted to collect emission data so as to identify the major sources of carcinogenic agents. The emission data for benzo (a) pyrene, one of the key carcinogens is shown in Table 10. The implications of this data are discussed in the HEW document Preliminary Air Pollution Survey of Organic Carcinogens (see also references cited). The key points with respect to stationary sources are:

(1) Inefficient coal combustion, e.g., in residential and small industrial coal-fired furnaces is the most important source of BaP.

(2) Efficient coal combustion in industrial-process boilers is not a significant source of emissions.

(3) Inefficient combustion in small incinerators and open burning results in considerable BaP formation. Efficient combustion in municipal incinerators results in very little BaP formation.

(4) Direct sampling of effluent from catalyst regenerators of petroleum catalytic crack units indicates that Houdriflow and Thermofor (air lift) units can be significant sources of BaP. Use of CO-waste heat boilers on individual regenerators can reduce these emissions to negligible amounts.

Polynuclear organics are also emitted from other specific industries, but these constitute only about 5% of the problem. Over 85% of polynuclear aromatic emissions are from heat generation processes.

The measures which may be effective in reducing these emissions include:

- Efficient fuel combustion
- Use of modern incinerators for all refuse disposal
- Use of carbon monoxide waste heater boilers to reduce emissions from petroleum catalytic cracking units.
- Thermal pretreatment of fuels to reduce BaP content.

The brief resume just given does no more than identify some of the areas of concern and hints at the scope of the problem. Further problem definition is required including analysis of the emission distribution and character, the efficacy of existing controls and the delineation of approaches to the problem. A hydrocarbon study along the lines of the one now in progress for hazardous pollutants is proposed.

## B. Odors

Virtually every industrial process *emits* some sort of odor, but only some of those odors are considered offensive. The chemical composition of these odors varies widely, making it difficult to collect, identify and determine annual emissions. Certain odors, such as that from hydrogen sulfide, can be quantified by tons of hydrogen sulfide emitted. Limited odor emission data is available and is usually quantified in terms of "odor units". Consequently, odor control techniques and control efficiency are presented here rather than trying to incorporate the information into the matrix.

Below are listed some common industrial sources of odors.

### Frequently Reported Odor Sources *

Animal Odors

- Meat packing and rendering plants
- Fish oil odors from manufacturing plants
- Poultry ranches and processing

Odors from Combustion Processes

- Gasoline and diesel engine exhaust
- Coke-oven and coal-gas odors (steel mills)
- Poorly adjusted heating systems

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* Taken from Ref. 33, Table 19

## Odors from Food Processing

- Coffee roasting plants
- Restaurants
- Bakeries

## Paint and Related Industries

- Manufacturing of paint, lacquer, and varnish
- Paint spraying
- Commercial solvents

## General Chemical Odors

- Hydrogen sulfide
- Sulfur dioxide
- Ammonia

## General Industrial Odors

- Burning rubber from smelting and debonding
- Odors from dry-cleaning shops
- Fertilizer plants
- Asphalt odors (roofing and street paving)
- Asphalt odors (manufacturing)
- Plastic manufacturing

## Foundry Odors

- Core-oven odors
- Heat treating, oil quenching, and pickling
- Smelting

- Odors from Combustion of Waste
  - Home incinerators and backyard trash fires
  - City incinerators burning garbage
  - Open-dump fires
- Refinery Odors
  - Mercaptans
  - Crude oil and gasoline
  - Sulfur
- Odors from Decomposition of Waste
  - Putrefaction and oxidation (organic acids*)
  - Organic nitrogen compounds (decomposition of protein*)
  - Decomposition of lignite (plant cells)
- Sewage Odors
  - City sewers carrying industrial waste
  - Sewage treatment plants.

The amount of odor emitted is generally represented as the number of odor units (o.u.). An odor unit describes the number of dilutions necessary to reduce the odor to a "threshold concentration", at which odor quality can be recognized by half of the members of an odor panel. Specifically then, the number of odor units is equal to the volumes (Scf) of air necessary to dilute the concentration of odorant in one volume of air to the threshold concentration. Odor emissions from typical industrial equipment in terms of odor units is tabulated in Table 11. For each operation typical odor control equipment is also indicated along with the resultant odor concentrations and odor emission rates. Odor removal efficiencies vary among the variously available devices. Table 12 lists some of the odor control methods and their effectiveness. Other data on efficiency is shown in Table 11. Typical data for a hypothetical dry rendering cooker is shown in Table 13.

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* Probably related to meat processing plants.

The extent to which sources of odors are controlled vary from industry to industry.

To summarize the information we can consider five major industry categories. Although the figures presented below are the result of a survey performed in England, the data give some idea of the effectiveness of control possible in the United States.

ANALYSIS OF CONTROL METHODS PRESENTLY EMPLOYED [143]

| | |
|---|---|
| I Offensive trades) (animal processing) | 51% controlled |
| II Food industry (brewery, cannery) | 29% controlled |
| III Chemical industry (paint, rubber) | 61% controlled |
| IV Metal industry (foundries, galvanizing) | 55% controlled |
| V Others (paper, refuse, textile, cement) | 26% controlled |
| Majority of cases without control are remote from population. | |

Because of the severity of the problem and the large number of complaints generated, there has been much attention given to rendering plants. There are approximately 800 rendering plants in the country producing both edible and inedible products. The emissions from these plants vary widely depending on the raw material used and the type of processing equipment. Generally, the more modern continuous processing units which are almost completely enclosed cause fewer odor emissions than the older, smaller batch rendering operations.

There are indications that odorous emissions constitute a hazard to health. Specific consequences have been reported including adverse respiratory effects, headaches [144] and increases in frequency of asthma attacks [144]. Accordingly, odor emission problems cannot be dismissed as merely nuisances, but rather a proper survey and problem definition is called for. A number of specific questions need to be addressed. These include:

1. Definition of problem scope - identification of key problems.
2. Identification of uniform and effective methods of odor measurement and characterization.
3. Definition of control system needs. Evaluation of available control systems, and determination of potentially profitable areas for development.

Because of the difficulties associated with measurements and because of the broad nature of the problem, odor emissions will be given separate consideration. A document is in preparation to define the broad outlines of the odor emissions problem in somewhat analogous fashion to the effort in the hydrocarbon area. Based on this it is hoped that we can proceed with a problem definition study which will reveal specific needs for R&D in all pertinent areas.

## V. SUMMARY

The data presented herein show that the ferrous and non-ferrous metals industries are prime sources of hazardous emissions, as are a number of processes involving combustion systems. A large percentage of emissions from controlled sources is in the form of fine particulate matter, which points up the need for special efforts to develop control along these lines.

Several major sources appear to be largely or completely uncontrolled. In some of these cases, for example, ore mining and handling, no well developed "off-the-shelf" control methods exist, which can be used directly. In other cases, a universal application of the best control system will result in eliminating some of the large particulate emissions. For the latter category, it may be true that economics, or questions of technological compatibility between the source and the control system need to be resolved before universal application of control is possible.

The control of hydrocarbons, and odors which are predominantly hydrocarbons present special problems, hydrocarbons because of the range and variety of the problem, odors because of the difficulties involved in identification and quantification.

At the present time, these two issues are being looked at in greater detail to prepare the outlines of a program planning effort.

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TABLE 5.1. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES -(CONT'D.)(1)

| CONSUMPTIVE USE (Continued) | TYPE IN USE | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORIDE COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General Laboratory Use of Mercury | None | 0 | 0 (M) | | | | | | | | | | | | | | 5(0.60) | | | | | | |
| Paint (Consumptive) | None, Except for Commercial Paint Shops Various | Neg | 0 (M) | | Unk | | | | | | | | | | | | 225(27.45) | | Unk | | | | |
| **INCINERATION** | | | | | | | | | | | | | | | | | | | | | | | |
| Industrial Large | Multiple Chamber Burning | 100 | Est Max 30 (43) | | Neg | | | | | | | | | | | | | | 211 67(.3) | | | | |
| Industrial Small | None | 0 | 0 (M) | | Neg | | | | | | | | | | | | | | | | | | |
| Domestic (Apartments) | None | 0 | 0 (43) | | Neg | | | | | | | | | | | | | | 730(0.2) | | | | |
| Domestic (Apartments) | Peabody Scrubber | Neg | 96 (43) | | Neg | | | | | | | | | | | | | | | | | | |
| Domestic (Homes) | None | 0 | 0 (43) | | Neg | | | | | | | | | | | | | | | | | | |
| Pathological | Afterburner or None | Unk | Unk | | | | | | | | | | | | | | | | Unk | | | | |
| Auto Body | Afterburner | Unk | Unk | | | | | | | | | | | | | | | | 2400(1.80) | | | | |
| Conical Burner | None | 0 | 0 (M) | | | | | | | | | | | | | | | | 2485(1.41) | | | | |
| Open Burning | None | 0 | 0 (M) | | Neg | | | | | | | | | | | | | | 52686(2.59) | | | | |
| Agricultural Burning | None | 0 | 0 (M) | | Unk | | | | | | | | | | | | | | 2361(4)(3.37) | | | | |
| Natural Fires (Forest) | None | 0 | 0 (M) | | Neg | | | | | | | | | | | | | | 16321(2)(17.87) | | | | |
| Natural Fires (Urban) | None | 0 | 0 (M) | | Neg | | | | | | | | | | | | | | 6060(3.13) | | | | |
| Highway Burners | None | 0 | 0 (M) | | Unk | | | | | | | | | | | | | | Unk | | | | |
| | | | | EFFICIENCIES Metals P.O.M. | | | | | | | | | | | | | | | | | | | |
| Municipal | None (Flue Settling Only) | 17 | 20 (43) | 2 (43) 10 (43) | | | | | | 95(1.15) | | | 660(3.42) | All Incinerators 320(3.45) | | | 135(17.04) (includes open burning) | | 68.4(0.2) | 17(0.12) (includes open burning) | | | 1700 (8.3) (includes open burning) |
| " | Dry Expansion Chamber | 22 | 20 (43) | 0 (43) 10 (43) | | | | | | | | | | | | | | | | | | | |
| " | Wet Bottom Expansion Chamber | 2 | 33 (43) | 4 (43) 22 (43) | | | | | | | | | | | | | | | | | | | |
| " | Spray Chamber | 12 100 | 40 (43) | 5 (43) 40 (43) | Neg | | | | | | | | | | | | | | | | | | |
| " | Wetted Wall Chamber | 17 | 35 (43) | 7 (43) 48 (43) | | | | | | | | | | | | | | | | | | | |
| " | Wetted, Close Spaced Baffles | 16 | 30 (43) | 10 (43) 85 (43) | | | | | | | | | | | | | | | | | | | |
| " | Dry Cyclone | 9 | 70 (43) | 0 (43) 25 (43) | | | | | | | | | | | | | | | | | | | |
| " | Medium Energy, Wet Scrubber | 5 | 90 (43) | 82 (43) 91 (43) | | | | | | | | | | | | | | | | | | | |
| Cotton Gin Waste (Arsenic) | Est. None | 0 | 0 (M) | | Unk | | | | | | | | | | | | | | Unk | | | | |
| Sewage and Sludge Burning | Est. None | 0 | 0 (M) | | Neg | | | | 20(.21) | | | | | | | 175(0.47) | 11(1.35) | | Unk | | | | 1750(1.10) |
| Coal Refuse Fire | None | 0 | 0 (M) | | Unk | | | | | | | | | | | | | | 1973(8)(4.03) | | | | |
| **COMBUSTION** | | | | | | | | | | | | | | | | | | | | | | | |
| Power Plants | | | | | | | | | | | | | | | | | | | | | | | |
| Pulverized Coal Boilers | Cyclones | 33.5 | 82.2 (43) | | 429(4.8) | | 2383(21.75) | 88(53.87) | 2655 (28.3) | | | 5576 (46.42) (M) | 585(4.35) | 7669 (15.81) | 6140(6.62) | 1409 (7.42) | 150(18.9) | 87(1.45) | [illegible] | 207([illegible]) | [illegible] (M) | [illegible] | 1427 ([illegible]) |
| " " " | ESP | 56.1 | 96 (43) | | | | | | | | | | | | | | | | | | | | |
| " " " | ESP Plus Cyclones | 16.6 100 | 96 (43) | | | | | | | | | | | | | | | | | | | | |
| " " " | Settling Chambers | Neg | Neg (43) | | | | | | | | | | | | | | | | | | | | |
| " " " | None | 4.1 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Stoker Fired Coal Boilers | ESP | 5.3 | | | 49(.55) | | 266(2.46) | 10(6.93) | 20(.21) | | | 6601(5.33) | 67(.50) | 2839 (1.22) | 7(0.17) | 162(0.85) | 17(2.15) | 49(0.57) | 10774(0.32) | 44(4.8) | 8([illegible]) (M) | [illegible] | 422(.24) |
| " " " " | Cyclones | 82.0 100 | 80 (43) | | | | | | | | | | | | | | | | | | | | |
| " " " " | None | 12.9 | | | | | | | | | | | | | | | | | | | | | |
| Cyclone Fired Coal Boilers | Cyclones | 11.2 | | | 15(.17) | | 80(.74) | 1(.08) | 8(.08) | | | 197(1.62) (M) | 20(.13) | 843 (0.54) | 211(0.23) | 48(0.26) | 6(.70) | 36(.27) | [illegible] | [illegible] | [illegible] (M) | [illegible] | [illegible] |
| " " " " | Cyclones Plus ESP | 55.1 100 | 91 (43) | | | | | | | | | | | | | | | | | | | | |
| " " " " | None | 28.4 | | | | | | | | | | | | | | | | | | | | | |
| Residual and Distillate Oil | None or Cyclones (For Soot Blowing) | Unk | Est 99 (43) | | | | 24(.22) | 2(1.39) | | | | 22(.18) (M) | 15(.11) | | 7(0.08) | 22(.11) | 1(.13) | 1961 (24.08) | 1675([illegible]) | 19(2.1) | 0 | [illegible] | 16(.10) |
| Natural Gas & LPG | None | 0 | 0 (43) | | | | None | | | | | | | | | | | | 6.3([illegible]) | | | | |
| Industrial | | | | | | | | | | | | | | | | | | | | | | | |
| Pulverized Coal Boilers | Multicyclones | 65.9 | 84.7 (43) | | 19(.21) | | 102(.94) | 8(5.55) | 118(1.2) | | | 247 (2.06) (M) | 26(.19) | 1094(0.68) | 27(0.29) | 62(0.33) | 6(.75) | 10(0.12) | [illegible] | [illegible] | [illegible] (M) | [illegible] | [illegible] |
| " " " | ESP | 29.6 100 | | | | | | | | | | | | | | | | | | | | | |
| " " " | None | 4.5 | | | | | | | | | | | | | | | | | | | | | |
| Stoker Fired Coal Boilers | Multicyclones | 57.6 | 84.7 (43) | | 47(.35) | | 359(3.31) | 13(9.03) | 411(4.3) | | | 866(7.23) (M) | 91(.68) | 3920(2.39) | 95(1.02) | 218(1.15) | 21(2.60) | 23(0.35) | [illegible] | 36([illegible]) | 2([illegible]) (M) | [illegible] | [illegible] |
| " " " " | ESP | 9.1 100 | | | | | | | | | | | | | | | | | | | | | |
| " " " " | None | 33.3 | | | | | | | | | | | | | | | | | | | | | |
| Cyclone Fired Coal Boilers | Multicyclones | 40.7 | 82.4 (43) | | 9(.10) | | 51(.47) | 2(1.39) | 59(.62) | | | 123(1.02) (M) | 13(.10) | 567(0.36) | 14(0.15) | [illegible] | 3(.38) | 8([illegible]) | [illegible] | 8([illegible]) | 2([illegible]) (M) | [illegible] | 55([illegible]) |
| " " " " | ESP | 49.8 100 | | | | | | | | | | | | | | | | | | | | | |
| " " " " | None | 9.5 | | | | | | | | | | | | | | | | | | | | | |
| Residual and Distillate Oil | None or Cyclones or ESP (For Soot Blow) | Unk | Est 99 (43) | | Neg | | 22(.20) | 2(1.39) | | | | 17(.14) (M) | 11(.08) | | 51(0.5) | 21([illegible]) | 1(.13) | 1139([illegible]) | 18000([illegible]) | [illegible] | 0 | 2760 ([illegible]) | 99(.07) |
| Natural Gas and LPG | None | 0 | 0 (43) | | | | None | | | | | | | | | | | | [illegible] | | | | |
| Residential/Commercial | | | | | | | | | | | | | | | | | | | | | | | |
| Coal | None | 0 | 2 (43) | | 6(.07) | | 32(.30) | 1(.69) | 37(.39) | | | 77(.64) (M) | 8(.06) | 362(0.22) | 9(.10) | 20(0.11) | 2(.25) | [illegible] | [illegible] | [illegible] | [illegible] | 16(.08) | 24([illegible]) |
| Oil | None | 0 | 0 (43) | | | | 49(.45) | 8(5.55) | | | | 38(.32) (M) | 25(.19) | | 17(.18) | 3(.02) | 2(.28) | 1925([illegible]) | [illegible] | 34(3.74) | 2([illegible]) (M) | [illegible] | 22([illegible]) |
| Gas | None | 0 | 0 (43) | | | | | | | | | | | | | | | | [illegible] | | | | |
| TOTAL (TONS) | | | | | 8939 | 6261 | 10826 | 144 | 9450 | 1018 | 78200 | 12007 | 13463 | 150218 | 9280 | 18991 | 792 | 5985 | 479[illegible] | 933 | 396 | 17673 | 150[illegible] |

M = MITRE Estimate   G = Private Communication, Dr. T. Gutman, Potomac River Regional Commission

(1) Source: The MITRE Corporation Preliminary Results EPA Contract No. 68-01-0438

(2) Sources of information for tabulated data are indicated by numbers in parentheses which refer to bibliography in Section VI.

(3) Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE I. MAGNITUDE OF HAZARDOUS

| CONSUMPTIVE USE (Continued) | TYPE IN USE | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORIDE COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLORINE | CHRO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General Laboratory Use of Mercury | None | 0 | 0 (M) | | | | | | | | | |
| Paint (Consumptive) | None, Except for Commercial Paint Shops-Various | Neg | 0 (M) | | Unk | | | | | | | |
| INCINERATION | | | | | | | | | | | | |
| Industrial/Large | Multiple Chamber Burning | 100 | Est Max 30(43) | | Neg | | | | | | | |
| Industrial/Small | None | 0 | 0 (M) | | Neg | | | | | | | |
| Domestic (Apartments) | *None* | 0 | 0 (43) | | Neg | | | | | | | |
| Domestic (Apartments) | Peabody Scrubber | Neg | 94 (43) | | Neg | | | | | | | |
| Domestic (Homes) | None | 0 | 0 (43) | | Neg | | | | | | | |
| Pathological | Afterburner or None | Unk | Unk | | | | | | | | | |
| Auto Body | Afterburner | Unk | Unk | | | | | | | | | |
| Conical Burner | None | 0 | 0 (M) | | | | | | | | | |
| Open Burning | None | 0 | 0 (M) | | Neg | | | | | | | |
| Agricultural Burning | None | 0 | 0 (M) | | Unk | | | | | | | |
| Natural Fires (Forest) | None | 0 | 0 (M) | | Neg | | | | | | | |
| Natural Fires *(Urban)* | None | 0 | 0 (M) | | Neg | | | | | | | |
| Wigwam Burners | None | 0 | 0 (M) | | Unk | | | | | | | |
| | | | | EFFICIENCIES<br>Metals P.O.M. | | | | | | | | |
| Municipal | None (Flue Settling Only) | 17 | 20 (43) | 2 (43) 10 (43) | | | | | | | | |
| " | Dry Expansion Chamber | 22 | 20 (43) | 0 (43) 10 (43) | | | | | | | | |
| " | *Wet Bottom* Expansion Chamber | 2 | 33 (43) | 4 (43) 20 (43) | | | | | | | | |
| " | Spray Chamber | 12 } 100 | 40 (43) | 5 (43) 40 (43) | Neg | | | | | 95(3.15) | | |
| " | Wetted Wall Chamber | 17 | 35 (43) | 7 (43) 48 (43) | | | | | | | | |
| " | Wetted, Close Spaced Baffles | 16 | 50 (43) | 10 (43) 85 (43) | | | | | | | | |
| " | Dry Cyclone | 9 | 70 (43) | 0 (43) 35 (43) | | | | | | | | |
| " | Medium Energy, Wet Scrubber | 5 | 90 (43) | 80 (43) 95 (43) | | | | | | | | |
| Cotton Gin Waste (Arsenic) | Est. None | 0 | 0 (4) | | Unk | | | | | | | |
| Sewage and Sludge Burning | Est. None | 0 | 0 (G) | | Neg | | | | 20(0.21) | | | |
| Coal Refuse Fire | None | 0 | 0 (M) | | Unk | | | | | | | |
| COMBUSTION | | | | | | | | | | | | |
| Power Plants | | | | | | | | | | | | |
| Pulverized Coal Boilers | Cyclones | 23.5 | 82.2 (43) | | | | | | | | | |
| " " " | ESP | 58.7 | 96 (43) | | | | | | | | | |
| " " " | ESP Plus Cyclones | 14.6 } 100 | 96 (43) | | 429(4.8) | | 2311(21.35) | 86(59.62) | 2655<br>(28.01) | | | 5571<br>(46.40<br>(M) |
| " " " | Settling Chambers | Neg. | Neg. (43) | | | | | | | | | |
| " " " | None | 3.1 | 0 (43) | | | | | | | | | |
| Stoker Fired Coal Boilers | ESP | 4.5 | | | | | | | | | | |
| " " " " | Cyclones | 82.6 } 100 | 80 (43) | | 49(.55) | | 266(2.46) | 10(6.93) | 304(3.21) | | | 640(5. |
| " " " " | None | 12.9 | | | | | | | | | | |
| Cyclone Fired Coal Boilers | Cyclones | 13.3 | | | | | | | | | | |
| " " " " | Cyclones Plus ESP | 57.3 } 100 | 91 (43) | | 15(.17) | | 80(.74) | 3(2.08) | 91(.96) | | | 192(1.6<br>(M) |
| " " " " | None | 29.4 | | | | | | | | | | |
| Residual and Distillate Oil | None or Cyclones (For Soot Blowing) | Unk | Est 99 (43) | | | | 29(.27) | 2(1.39) | | | | 22(.18)<br>#43 |
| Natural Gas & LNG | None | 0 | 0 (43) | | | | None | | | | | |
| Industrial | | | | | | | | | | | | |
| Pulverized Coal Boilers | Multicyclones | 65.9 | 84.7 (43) | | | | | | | | | |
| " " " | ESP | 29.6 } 100 | | | 19(.21) | | 102(.94) | 8(5.55) | 118(1.25) | | | 247 (2.<br>(M) |
| " " " | None | 4.5 | | | | | | | | | | |
| Stoker Fired Coal Boilers | Multicyclones | 52.6 | | | | | | | | | | |
| " " " " | ESP | 9.1 } 100 | 84.7 (43) | | 67(.75) | | 358(3.31) | 13(9.01) | 413(4.36) | | | 864(7.2<br>(M) |
| " " " " | None | 38.3 | | | | | | | | | | |
| Cyclone Fired Coal Boilers | Multicyclones | 40.7 | 82.4 (43) | | | | | | | | | |
| " " " " | ESP | 49.8 } 100 | | | 9(.10) | | 51(.47) | 2(1.39) | 59(.62) | | | 123(1.0<br>(M) |
| " " " " | None | 9.5 | | | | | | | | | | |
| Residual and Distillate Oil | None or Cyclone or ESP (For Soot Blow) | Unk | Est 99 (43) | | Neg | | 22(.20) | 2(1.39) | | | | 17(.14)<br>#43 |
| Natural Gas and LNG | None | 0 | 0 (43) | | | | None | | | | | |
| Residential/Commercial | | | | | | | | | | | | |
| Coal | None | 0 | 0 (43) | | 6(.07) | | 32(.30) | 1(.69) | 37(.39) | | | 77(.64)<br>(M) |
| Oil | None | 0 | 0 (43) | | | | 49(.45) | 8(5.55) | | | | 38(.32)<br>#43 |
| Gas | None | 0 | 0 (43) | | | | | | | | | |
| TOTAL (TONS) | | | | | 8939 | 6261 | 10826 | 144 | 9480 | 3018 | 78200 | 12007 |

M - MITRE Estimate    G - Private Communication, Dr. Y. Gordon
Potomac River Regional Commission

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) Sources of information for tabulated data are

(3) Underlined numbers in parentheses show percent

TABLE I. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES -(CONT'D)$^{(1)}$

| LLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 51(6.44) | 3) | | | | | |
| | | | | | | | | | 215(27.15) | | Unk | | | | |
| | | | | | | | | | | | 2228(0.05) | | | | |
| | | | | | | | | | | | 730(0.02) | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | | | | | | | | | | 14602(0.30) | | | | |
| | | | | | | | | | | | 212211(4.42) | | | | |
| | | | | | | | | | | | 526843(10.98) | | | | |
| | | | | | | | | | | | 2161142(45.05) | | | | |
| | | | | | | | | | | | 1433712(29.89) | | | | |
| | | | | | | | | | | | 6060(0.13) | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | 95(3.15) | | | 460(3.42) | All Incinerators 320(3.45) | | | 135(17.04) (includes open burning) | | 682(0.01) | 1(0.12) (includes open-burning) | | | 27700 (18.39) (includes open-burning) |
| | | | | | | | | | | | Unk | | | | |
| | 20(0.21) | | | | | | | 175(0.92) | 11(1.39) | | Unk | | | | |
| | | | | | | | | | | | 193500(4.03) | | | | 1750(1.16) |
| 0.62) | 2655 (28.01) | | | 5571 (46.40) (M) | 585(4.35) | 24696 (15.41) | 614(6.62) | 1409 (7.42) | 150(18.94) | 87(1.45) | 8980(.19) | 360(42.11) | 68(19.10) (M) | 1013 (5.67) | 2457 (1.63) |
| .93) | 304(3.21) | | | 640(5.33) | 67(.50) | 2839 (1.77) | 71(0.77) | 162(0.85) | 17(2.15) | 10(0.17) | 1032(0.02) | 41(4.80) | 8(2.25)(M) | 116(.65) | 282(0.19) |
| .08) | 91(.96) | | | 192(1.60) (M) | 20(.15) | 852 0.53) | 21(0.23) | 49(0.26) | 6(.76) | 3(0.05) | 310(0.01) | 12(1.40) | 2(0.56)(M) | 35(.20) | 85(.06) |
| .39) | | | | 22(.18) #43 | 15(.11) | | 7(0.08) | 2(0.01) | 1(.13) | 1441 (24.08) | 7675(0.16) | 19(2.22) | 0 | 4930 (27.58) | 130(.09) |
| | | | | | | | | | | | 6151(0.13) | | | | |
| .55) | 118(1.25) | | | 247 (2.06) (M) | 26(.19) | 1092(0.68) | 27(0.29) | 62(0.33) | 6(.76) | 7(0.12) | 1896(0.04) | 16(1.87) | 3(0.84) (M) | 45(.25) | 109(07) |
| .01) | 413(4.36) | | | 864(7.20) (M) | 91(.68) | 3830(2.39) | 95(1.02) | 218(1.15) | 23(2.90) | 23(0.38) | 6635(0.14) | 56(6.55) | 11(3.09) (M) | 158(.88) | 382(.25) |
| .39) | 59(.62) | | | 123(1.02) (M) | 13(.10) | 547(0.34) | 14(0.15) | 31(0.16) | 3(.38) | 3(0.05) | 948(0.02) | 8(0.94) | 2(0.56) (M) | 23(.13) | 55(.04) |
| .39) | | | | 17(.14) #43 | 11(.08) | | 5(.05) | 2(0.01) | 1(.13) | 1139(19.03) | 10001 (0.21) | 15(1.75) | 0 | 2740 (15.33) | 99(.07) |
| | | | | | | | | | | | 20220(0.42) | | | | |
| 9) | 37(.39) | | | 77(.64) (M) | 8(.06) | 342(0.21) | 9(.10) | 20(0.11 | 2(.25) | 3(0.05) | 66796(1.39) | 5(0.59) | 1(0.29)(M) | 14(.08) | 34(.02) |
| .55) | | | | 38(.32) #43 | 25(.19) | | 12(.13) | 3(.02) | 3(.38) | 2435(40.69) | 33105(0.69) | 32(3.74) | 1(0.29) #43 | 8330 (46.61) | 221(.15) |
| | | | | | | | | | | | 10065(0.21) | | | | |
| | 9480 | 3018 | 78200 | 12007 | 13463 | 160218 | 9280 | 18993 | 792 | 5985 | 4797104 | 855 | 356 | 17873 | 150656 |

Sources of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

## TABLE 1. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES (1)

| INDUSTRY AND PROCESS | CONTROL DEVICES | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING AND RAW MATERIAL PREPARATION | TYPE IN USE | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORIDE COLLECTION | ARSENIC (#6)(2) | ASBESTOS (#3) | BARIUM (#9) | BERYLLIUM (#5) | BORON (#10) | CADMIUM (#1) | CHLORINE (#49) | CHROMIUM (#65) | COPPER (#11) | FLUORIDES (#50) | LEAD (#67) | MANGANESE (#6) | MERCURY (#7) | NICKEL (#2) | POM (#68) | SELENIUM (#12) | TIN (#36) | VANADIUM (#8) | ZINC (#12) |
| Copper | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | <1 | | | | | Neg<br>Neg | | | 190(1.61)(3) | | See Lead | | | | | | | | |
| Zinc | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, Baghouse | 35 | 90 (43) | | <1 | | | | | Neg | | | | | See Lead | | | | | | | | |
| Lead | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | <1 | | | | | Neg<br>Neg | | | | | 365(3.72) | | | | | | | | 74([illegible]) |
| Iron Ore | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | | | | | | | | | | | | | | | | | | | |
| Pellet Plants | " " " " " | (Est. 75% net control) | (43) | | | | | | | | | | | | | | | | | | | | |
| Coal | | | | | | | | | | | | | | 10200(11.36) | | | | | | | | | |
| Mining and Handling | None | 0 | 0 (43) | | Unk | | Unk | Unk | Unk | Unk | | | | | | | | | | | | | |
| Coal Cleaning | Cyclone Plus Wet Scrubber | 35 (8) | Est 90-95 (43) | | | | | | | | | | | | | | | | | | | | |
| " " | Cyclone Only | 90 (8) | Est 90-92 (43) | | | | | | | | | | | | | | | | | | | | |
| Asbestos Mining | | | | | | | | | | | | | | | | | | | | | | | |
| Crushing and Drying | Cyclones | Est. 100 (3) | Est 90 (8) | | | | | | | | | | | | | | | | | | | | |
| Milling | Cyclones and Baghouse | Est. 100 (3) | Est 95-99 (8) | | | | | | | | | | | | | | | | | | | | |
| Handling and All Other | None | 0 (3) | 0 (3) | | | 5610(29.4) | | | | | | 8(0.07) | | | | | | | | | | | |
| Barium Mining | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (8) | | | | | | | | | | | | | | | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | Est. 35 | 90 (8) | | | | 30(0.28) | | | | | | | | | | | | | | | | |
| Mica, Feldspar, Mining (Beryllium) | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (8) | | | | | | | | | | | | | | | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | Est 100 | 90 (8) | | | | | Nil<br>(neg) | | | | | | | | | | | | | | | |
| Borax Mining | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing | Baghouse | Est 100 (12) | 99 (8) | | | | | | | | | | | | | | | | | | | | |
| Other Mining Operations | None | 0 (12) | 0 (12) | | | | | | 100(1.07) | | | | | | | | | | | | | | |
| Manganese Mining (90-95% Imported) | | | | | | | | | | | | | | | | | | | | | | | |
| Tailing Wind Loss | None | 0 (6) | 0 (6) | | | | | | | | | | | | | | | | | | | | |
| Other Mining Operations | Hood, Chambers, Cyclones, ESP, Baghouse | Est 100 (6) | 99 (8) | | | | | | | | | | | | | 5(0.93) | | | | | | | |
| Nickel Mining | Hood, Chambers, Cyclones, ESP, Baghouse | Est 35 (8) | 90 (8) | | | | | | | | | | | | | | | 2(0.03) | | | | | |
| Phosphate Rock | | | | | | | | | | | | | | | | | | | | | | | |
| Grinding | Cyclones and/or Wet Scrubbers | 100 | 96 (43) | | | | | | | | | | | | | | | | | | | | |
| Drying | " " | 100 | 97 (43) | | | | | | | | | | | | | | | | | | | | |
| Handling | Hood, Cyclones, Wet Scrubbers | 25 | 99 (43) | | Neg. | | | | | | | | | | | | | | | | | | |
| Calcining | Hood, Cyclones, Wet Scrubbers | 100 | 93 (43) | | | | | | | | | | | | | | | | | | | | |
| Defluorination of Phosphate Rock | High Energy Wet Scrubbers | Est. 100 | 86 (43) | | | | | | | | | | | 1760(1.10) | | | | | | | | | |
| Mercury Mining | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing and Grinding | Hood, Chambers, Cyclones, ESP, Baghouse | Est 35 | 90 (8) | | | | | | | | | | | | | | | | | | | | |
| Other Mining Operations | " " " " " | Est 35 | 90 (8) | | | | | | | | | | | | | | 2.6(.33) | | | | | | |
| Vanadium Mining | | | | | | | | | | | | | | | | | | | | | | | |
| Ore Crushing and Grinding | Hood, Chambers, Cyclones, ESP, Baghouse | Est 35 | 90 (8) | | | | | | | | | | | | | | | | | | | | |
| Other Mining Operations | " " " " " | Est 35 | 90 (8) | | | | | | | | | | | | | | | | | | | Neg | |
| Primary Aluminum | | | | | | | | | | | | | | | | | | | | | | | |
| Calcining of Hydroxide | Cyclones, ESP, Baghouse | (Est 97% Net Control) | (43) | | | | | | | | | | | | | | | | | | | | |
| Reduction H.S. Soderberg | Floating Bed Scrubber | Small | 80-90 (43) | 90 (50) | | | | | | | | | | | | | | | | | | | |
| " | Wet Plate Electrostatic | Small | 90 (43) | 99 (50) | | | | | | | | | | | | | | | | | | | |
| " | Spray Scrubber | Approx. 100 | 40-50 (43) | 85-90 (50) | | | | | | | | | | 3160(3.22) | | | | | | | | | |
| Reduction V.S. Soderberg | Multicyclone | Approx. 100 | 65 (43) | 0 (50) | | | | | | | | | | | | | | | | | | | |
| " | Spray Scrubber | Approx. 100 | 40-50 (43) | 85-90 (50) | | | | | | | | | | 2400(1.56) | | | | | | | | | |
| " | Sieve Plate Scrubber | Small | 75 (43) | 95 (50) | | | | | | | | | | | | | | | | | | | |
| Prebake | Multicyclone | | 80 (43) | 0 (50) | | | | | | | | | | | | | | | | | | | |
| " | Dry Electrostatic | Approx. 100 | 95 (43) | Unk (50) | | | | | | | | | | | | | | | | | | | |
| " | Spray Scrubber Plus Multicyclone | Approx. 100 | 60-70 (43) | 80-90 (50) | | | | | | | | | | 8420(5.37) | | | | | Unk | | | | |
| " | Spray Scrubber Plus ESP | Approx. 100 | 10 (43) | 85-90 (50) | | | | | | | | | | | | | | | | | | | |
| " | Dry Exhaust and Baghouse | Small | 98-99 (43) | 99 (50) | | | | | | | | | | | | | | | | | | | |
| " | Countercurrent Packed Scrubber | Small | 95 (43) | 90 (50) | | | | | | | | | | | | | | | | | | | |
| All Reduction Processes | Roof Monitor Spray Mesh Filter | Small | 0 (43) | 60-70 (50) | | | | | | | | | | | | | | | | | | | |
| " | Roof Monitor-ESP Plus Wet Filter | Small | Est 50 (43) | 90 (50) | | | | | | | | | | | | | | | | | | | |
| Raw Material Handling | Cyclones or Baghouse | 35 | 90 (43) | Unk (50) | | | | | | | | | | | | | | | | | | | |

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(1) Source: The MITRE Corporation
Preliminary Analysis
EPA Contract No. 68-02-0428

(2) Sources of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section V.

(3) Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE I. MAGNITUDE OF

| INDUSTRY AND PROCESS | CONTROL DEVICES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING AND RAW MATERIAL PREPARATION | TYPE IN USE | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORIDE COLLECTION | ARSENIC (#4)[2] | ASBESTOS (#3) | BARIUM (#9) | BERYLLIUM (#5) | BORON (#10) | CADMIUM (#1) | CHLORINE (#49) |
| Copper | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | <1 | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | | | | | | Neg<br>Neg | |
| Zinc | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | <1 | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, Baghouse | 35 | 90 (43) | | | | | | | .4<br>Neg | |
| Lead | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | <1 | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | | | | | | Neg<br>Neg | |
| Iron Ore | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (43) | | | | | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | | | | | | | |
| Pellet Plants | " " " " " | (Est. 75% net control) | (43) | | | | | | | | |
| Coal | | | | | | | | | | | |
| Mining and Handling | None | 0 | 0 (43) | | Unk | | Unk | Unk | Unk | Unk | |
| Coal Cleaning | Cyclone Plus Wet Scrubber | 50 100 | Est 90-95 (43) | | | | | | | | |
| " " | Cyclone Only | 50 | Est 50-60 (43) | | | | | | | | |
| Asbestos Mining | | | | | | | | | | | |
| Crushing and Drying | Cyclones | Est. 100 (3) | Est 90 (M) | | | 5610(89.6) | | | | | |
| Milling | Cyclones and Baghouse | Est. 100 (3) | Est 95-99 (M) | | | | | | | | |
| Handling and All Other | None | 0 (3) | 0 (3) | | | | | | | | |
| Barium Mining | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (M) | | | | 30(0.28) | | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | Est. 35 | 90 (M) | | | | | | | | |
| Mica, Feldspar, Mining (Beryllium) | | | | | | | | | | | |
| Ore Crushing | None | 0 | 0 (M) | | | | | NEG<br>(neg) | | | |
| Raw Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | Est 100 | 90 (M) | | | | | | | | |
| Borax Mining | | | | | | | | | | | |
| Ore Crushing | Baghouse | Est 100 (10) | 99 (M) | | | | | | 100(1.05) | | |
| Other Mining Operations | None | 0 (10) | 0 (10) | | | | | | | | |
| Manganese Mining (98-99% Imported) | | | | | | | | | | | |
| Tailing Wind Loss | None | 0 (6) | 0 (6) | | | | | | | | |
| Other Mining Operations | Hood, Chambers, Cyclones, ESP, Baghouse | Est 100 (6) | 99 (M) | | | | | | | | |
| Nickel Mining | Hood, Chambers, Cyclones, ESP, Baghouse | Est 35 (M) | 90 (M) | | | | | | | | |
| Phosphate Rock | | | | | | | | | | | |
| Grinding | Cyclones and/or Wet Scrubbers | 100 | 94 (43) | | Neg. | | | | | | |
| Drying | " " | 100 | 97 (43) | | | | | | | | |
| Handling | Hood, Cyclones, Wet Scrubbers | 25 | 90 (43) | | | | | | | | |
| Calcining | Hood, Cyclones, Wet Scrubbers | 100 | 95 (43) | | | | | | | | |
| Defluorination of Phosphate Rock | High Energy Wet Scrubbers | Est 100 | 84 (43) | | | | | | | | |
| Mercury Mining | | | | | | | | | | | |
| Ore Crushing and Grinding | Hood, Chambers, Cyclones, ESP, Baghouse | Est 35 | 90 (M) | | | | | | | | |
| Other Mining Operations | " " " " " | Est 35 | 90 (M) | | | | | | | | |
| Vanadium Mining | | | | | | | | | | | |
| Ore Crushing and Grinding | Hood, Chambers, Cyclones, ESP, Baghouse | Est 35 | 90 (M) | | | | | | | | |
| Other Mining Operations | " " " " " | Est 35 | 90 (M) | | | | | | | | |
| Primary Aluminum | | | | | | | | | | | |
| Calcining of Hydroxide | Cyclones, ESP, Baghouse | (Est 90% Net Control) | (43) | | | | | | | | |
| Reduction H.S.Soderberg | Floating Bed Scrubber | Small | 80-90 (43) | 90 (50) | | | | | | | |
| " | Wet Plate Electrostatic | Small | 90 (43) | 99 (50) | | | | | | | |
| " | Spray Scrubber | Approx. 100 | 40-50 (43) | 80-90 (50) | | | | | | | |
| Reduction V.S. Soderberg | Multicyclone | Approx. 100 | 60 (43) | 0 (50) | | | | | | | |
| " | Spray Scrubber | Approx. 100 | 40-50 (43) | 80-90 (50) | | | | | | | |
| " | Sieve Plate Scrubber | Small | 70 (43) | 95 (50) | | | | | | | |
| Prebake | Multi-cyclone | | 60 (43) | 0 (50) | | | | | | | |
| " | Dry Electrostatic | Approx. 100 | 90 (43) | Unk (50) | | | | | | | |
| " | Spray Scrubber After Multicyclone | Approx. 100 | 40-50 (43) | 80-90 (50) | | | | | | | |
| " | Spray Scrubber After ESP | Approx. 100 | 10 (43) | 80-90 (50) | | | | | | | |
| " | Cell Exhaust and Baghouse | Small | 96-98 (43) | 99 (50) | | | | | | | |
| " | Counterflow Packed Scrubber | Small | 95 (43) | 90 (50) | | | | | | | |
| All Reduction Processes | Roof Monitor-Spray Mesh Filter | Small | 0 (43) | 60-70 (50) | | | | | | | |
| " | Roof Monitor-ESP Plus Wet Filter | Small | Est 50 (43) | 90 (50) | | | | | | | |
| Raw Material Handling | Cyclones or Baghouse | 35 | 90 (43) | Unk (50) | | | | | | | |

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) Sources of information for tabulated data are indicated

(3) Underlined numbers in parentheses show percentage of all

TABLE I. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES (1)

| BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (#5) | (#10) | (#1) | (#49) | (#45) | (#11) | (#50) | (#47) | (#6) | (#7) | (#2) | (#48) | (#12) | (#56) | (#8) | (#13) |
|  |  | Neg |  |  | 190(1.41)(3) |  | See Lead |  |  |  |  |  |  |  |  |
|  |  | Neg |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | .4 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | Neg |  |  |  |  | See Lead |  |  |  |  |  |  |  | 72(0.05) |
|  |  | Neg |  |  |  |  | 345(3.72) |  |  |  |  |  |  |  |  |
|  |  | Neg |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 18200(11.36) |  |  |  |  |  |  |  |  |  |
| Unk | Unk | Unk |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | 8(0.07) |  |  |  |  |  |  |  |  |  |  |  |
| NEG<br>(neg) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 100(1.05) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | 5(0.03) |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 2(0.03) |  |  |  |  |  |
|  |  |  |  |  |  | 1760(1.10) |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | 2.6(.33) |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  | Neg |  |
|  |  |  |  |  |  | 5160(3.22) |  |  |  |  | Unk |  |  |  |  |
|  |  |  |  |  |  | 2460(1.54) |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 8610(5.37) |  |  |  |  |  |  |  |  |  |

information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE 4.1. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES - (CONT'D) (1)

| INDUSTRY AND PROCESS | CONTROL DEVICES | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING AND RAW MATERIAL PREPARATION | TYPE IN USE | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORIDE COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
| Zinc Chemicals | Cyclones, Wet ESP, Baghouse | Est 90-100 | Est 85-95 (M) | | | | | | | | | | | | | | | | | | | | [illegible] |
| Cadmium Paint Pigments | Baghouse | 100 (1) | 95-99 (M) | | | | | | | 10.5(0.35)(3) | | | | | | | | | | | | | |
| Misc. Copper Metals and Alloys | Cyclones, ESP, Baghouse | Est 80-100 | 85-95 (M) | | | | | | | | | | 2(0.02) | | | | | | Unk | | | | |
| Cadmium-Barium Plastic Stabilizers | Baghouse | 100 (1) | 90-99 (M) | | | | | | | 3(0.10) | | | | | | | | | | | | | |
| Primary Chromium | (Assumed Similar To Copper) | | | | | | | | | | | | | | | | | | | | | | |
| Production | Hoods, Baghouse | Est 70-80 | Est 90-95(22,M) | | | | | | | | | 4200(34.95) | | | | | | | Unk | | | | |
| Handling | " " | Est 70-80 | Est 90-95(21,M) | | | | | | | | | | | | | | | | | | | | |
| Petroleum Refining | Afterburners | Est 100 (M) | Unk | | | | | | | | | | | | 1250(13.47) | | | | 2170(0.05) | | | | |
| Lead Alkyl Chemicals | Scrubbers, Conl. Baghouse | Est 100 (M) | Est 68 (M) | | | | | | | | | | | | 810(8.73) | | | | Unk | | | | |
| Lead Storage Batteries | Most Uncontrolled, Conl. Scrubbers | Unk (M) | Unk (M) | | | | | | | | | | | | Unk | | | | | | | | |
| Dry Storage Batteries | Unk | Unk | Unk | | | | | | | | | | | | | 90(0.47) | | | | | | | |
| Expanded Clay Aggregate | None Conl. Spray Scrubber | Neg | 80 (43) | | | | | | | | | | | 1500(3.31) | | | | | | | | | |
| Diammonium Phosphate | Ammonia Scrubber Plus Wet Scrubber | Unk | 87 (30) | | | | | | | | | | | 280(0.18) | | | | | | | | | |
| Triple Superphosphate | Cyclones | Unk | 74 (30) | | | | | | | | | | | 3780(2.36) | | | | | | | | | |
| Normal Superphosphate | Wet Scrubber (Gas) Cyclone, Baghouse (Dust) | Unk | 80 (30) | | | | | | | | | | | 4970(3.10) | | | | | | | | | |
| Elemental Phosphorus | Hoods, Wet Scrubbers | Unk | 84 (30) | | | | | | | | | | | 4080(2.55) | | | | | | | | | |
| Beryllium Alloys & Compounds | Cyclones, Scrubber, Baghouse | 100 | Est 99 (1) | | | | | 5.25(3.56) | | | | | | | | | | | Unk | | | | |
| END PRODUCT FABRICATION | | | | | | | | | | | | | | | | | | | | | | | |
| Cement Kilns | | | | | | | | | | | | | | | | | | | | | | | |
| Wet and Dry | Cyclone | 17 | 70 (43) | | | | | | | | | | | 270(0.17) | | | | | | | | | |
| " | ESP or Cyclone and ESP | 61 (100) | 99 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Baghouse | 18 | 99 (43) | | | | | | | | | | | | | | | | | | | | |
| " | None | 4 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Material Handling & Transport | Baghouse | Est Low | 99 (43) | | | | | | | | | | | Neg | | | | | | | | | |
| " | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Chlorine Bleach Manufacture | Return Vents & Alkali Scrubbers | Est 100 | 95-100(M,24) | | | | | | | | 900(1.11) | | | | | | | | Unk | | | | |
| Asbestos Products | | | | | | | | | | | | | | | | | | | | | | | |
| Brake Lining Production | Hoods, Cyclones, Baghouse | Est 100 | Est 95-99(M) | | | 312(4.98) | | | | | | .5(Neg) | | | | | | | | | | | |
| Shingles & Siding Products | " " " | Est 100 | Est 95-99(M) | | | 205(3.27) | | | | | | .3(Neg) | | | | | | | | | | | |
| Asbestos Textiles | " " " | Est 100 | Est 95-99(M) | | | 18(0.29) | | | | | | Neg | | | | | | | | | | | |
| Arsenic Pesticides | Hood, Baghouse | Est 100 | Est 95-99(M) | | 197(2.20) | | | | | | | | | | | | | | | | | | |
| Paint, Varnish, Enamel, Lacquer | None, Cyclones, Baghouses | Est 55 | 99 (9) | | | | 30(0.28) | | | | | | | | | | 11(.13) | | | 1(0.12) | | | [illegible] |
| Beryllium Metal & Alloy Fabrication | Cyclones, Baghouses, Absolute Filter | 100 | Near 100 (5) | | | | | 39 lbs(Neg) | | | | | | | | | | | | | | | |
| Soaps and Detergents | Scrubbers, Baghouses | Unk | Unk | | Neg | | | | 13(0.14) | | | | | | | | | | Unk | | | | |
| Cadmium-Nickel Batteries | Unk | Unk | Unk | | | | | | | 600 lbs(0.01) | | | | | 2(0.02) | | | | | | | | |
| Misc. Tin Products | Unk | Unk | Unk | | | | | | | | | | | | | | | | | | Unk | | |
| Misc. Cadmium Products | Various | Unk | Unk | | | | | | | 1128 lbs(0.02) | | | | | | | | | | | | | |
| Misc. Chlorine Products | Various | Est 100 (M) | Unk | | Neg | | | | | | 1000(1.28) | | | | | | | | Unk | | | | |
| Refractory Bricks | Baghouse | 100 | 99 (25) | | | | | | | | | 7.3(0.06) | | | | | | | | | | | |
| Structural Clay Products | None, Conl. Spr. Scrubbers | Neg | 80 (43) | | | | | | | | | | | 9720(6.07) | | | | | | | | | |
| Instrument Manufacture | Unk | Unk | Unk | | | | | | | | | | | | | | 2.6(.13) | | | | | | |
| Electrical Apparatus | Unk | Unk | Unk | | | | | | | | | | | | | | 3(.04) | | | | | | |
| Dental Preparations | Unk | Unk | Unk | | | | | | | | | | | | | | 1.2(.15) | | | | | | |
| Misc. Copper Chemicals and Products | Cyclones, ESP, Baghouse | Est 80-100 (M) | 85-95 (M) | | | | | | | | | | 230(1.71) | | | | | | | | | | |
| Welding Rods | Cyclones, ESP, Baghouse | Est Small (M) | Est Neg (M) | | | | | | | | | | | | | 26(0.13) | | | Unk | | | | |
| CONSUMPTIVE USE | | | | | | | | | | | | | | | | | | | | | | | |
| Installation of Asbestos Construction Material | None | 0 | 0 (3) | | | 61(0.97) | | | | | | .1(Neg) | | | | | | | | | | | |
| Spray on Steel Fireproofing | Temporary Enclosures | Est 80-100 | Unk (3) | | | 15(0.24) | | | | | | Neg | | | | | | | | | | | |
| Insulating Cement, Asbestos Type | Depends on Where Applied in System | (Est. 99% Not Controlled)(3) | | | | 25(0.40) | | | | | | Neg | | | | | | | | | | | |
| Pesticides, Herbicides, Fungicides | None | 0 | 0 (M) | | 2925(32.72) | | | | 1800(18.99) | 500 lbs (0.01) | | | | | Neg | | 19.1(.10) | | Unk | | | | |
| Well Drilling Mud | None Emissions .01% of Consumption | 0 | 0 (M) | | | | 30(.65) | | | | | | | | | | | | | | | | |
| Fertilizer Application | None | 0 | 0 (M) | | | | | | | 910 lbs (0.02) | | | | | | | | | Unk | | | | |
| Pharmaceuticals | None | 0 | 0 (M) | | | | | | | | | | | | | | 2.6(.13) | | | | | | |

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) Sources of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

(3) Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE I. MAGNITUDE OF

| INDUSTRY AND PROCESS | CONTROL DEVICES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING AND RAW MATERIAL PREPARATION | TYPE IN USE | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORIDE COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLOR |
| Zinc Chemicals | Cyclones, Wet ESP, Baghouse | Est 95-100 | Est 85-95 (M) | | | | | | | | |
| Cadmium Paint Pigments | Baghouses | 100 (1) | 90-99 (M) | | | | | | | 10.5(0.35) (3) | |
| Misc. Copper Metals and Alloys | Cyclones, ESP, Baghouse | Est 80-100 | 85-95 (M) | | | | | | | | |
| Cadmium-Barium Plastic Stabilizers | Baghouses | 100 (1) | 90-99 (M) | | | | | | | 3(0.10) | |
| Primary Chromium | (Assumed Similar To Copper) | | | | | | | | | | |
| Production | Hoods, Baghouses | Est 70-80 | Est 90-95 (25,M) | | | | | | | | |
| Handling | " " | Est 70-80 | Est 90-95(25,M) | | | | | | | | |
| Petroleum Refining | Afterburners | Est 100 (M) | Unk | | | | | | | | |
| Lead Alkyl Chemicals | Scrubbers, Ocnl. Baghouse | Est 100 (M) | Est 88 (M) | | | | | | | | |
| Lead Storage Batteries | Most Uncontrolled, Ocnl. Scrubbers | Unk (M) | Unk (M) | | | | | | | | |
| Dry Storage Batteries | Unk | Unk | Unk | | | | | | | | |
| Expanded Clay Aggregate | None (Ocnl. Spray Scrubber) | Neg | 80 (43) | | | | | | | | |
| Diammonium Phosphate | Ammonia Scrubber Plus Wet Scrubber | Unk | 82 (50) | | | | | | | | |
| Triple Superphosphate | Cyclones | Unk | 74 (50) | | | | | | | | |
| Normal Superphosphate | Wet Scrubber (Gas) Cyclone, Baghouse (Dust) | Unk | 80 (50) | | | | | | | | |
| Electrothermal Phosphorus | Hoods, Wet Scrubbers | Unk | 84 (50) | | | | | | | | |
| Beryllium Alloys & Compounds | Cyclone, Scrubber, Baghouse | 100 | Est 99 (5) | | | | | 5.25(3.64) | | | |
| END PRODUCT PRODUCTION | | | | | | | | | | | |
| Cement Kilns | | | | | | | | | | | |
| Wet and Dry | Cyclone | 17 | 70 (43) | | | | | | | | |
| " | ESP or Cyclone and ESP | 61 } 100 | 99 (43) | | | | | | | | |
| " | Baghouse | 16 | 99 (43) | | | | | | | | |
| " | None | 6 | 0 (43) | | | | | | | | |
| Material Handling & Transport | Baghouse | Est Low | 99 (43) | | | | | | | | |
| " | None | 0 | 0 (43) | | | | | | | | |
| Chlorine Bleach Manufacture | Return Vents & Alkali Scrubbers | Est 100 | 95-100(M,24) | | | | | | | | |
| Asbestos Products | | | | | | | | | | | 900(1.15) |
| Brake Lining Production | Hoods, Cyclones, Baghouse | Est 100 | Est 95-99(M) | | | 312(4.98) | | | | | |
| Shingles & Siding Products | " " " | Est 100 | Est 95-99 (M) | | | 205(3.27) | | | | | |
| Asbestos Textiles | " " " | Est 100 | Est 95-99 (M) | | | 18(0.29) | | | | | |
| Arsenic Pesticides | Hood, Baghouse | Est 100 | Est 95-99(M) | | 197(2.20) | | | | | | |
| Paint, Varnish, Enamel, Lacquer | None, Cyclones, Baghouses | Est 55 | 99 (9) | | | | 30(0.28) | | | | |
| Beryllium Metal & Alloy Fabrication | Cyclone, Baghouse, Absolute Filter | 100 | Near 100 (5) | | | | | 39 lbs(Neg) | | | |
| Soaps and Detergents | Scrubbers, Baghouses | Unk | Unk | | Neg | | | | 13(0.14) | | |
| Cadmium-Nickel Batteries | Unk | Unk | Unk | | | | | | | | |
| Misc. Tin Products | Unk | Unk | Unk | | | | | | | 400 lbs(0.01) | |
| Misc. Cadmium Products | Various | Unk | Unk | | | | | | | | |
| Misc. Chlorine Products | Various | Est 100 (M) | Unk | | Neg | | | | | 1128 lbs(0.02) | |
| Refractory Bricks | Baghouse | 100 | 99 (25) | | | | | | | | 100C(1.28) |
| Structural Clay Products | None, Ocnl. Spray Scrubbers | Neg. | 80 (43) | | | | | | | | |
| Instrument Manufacture | Unk | Unk | Unk | | | | | | | | |
| Electrical Apparatus | Unk | Unk | Unk | | | | | | | | |
| Dental Preparations | Unk | Unk | Unk | | | | | | | | |
| Misc. Copper Chemicals and Products | Cyclones, ESP, Baghouse | Est 80-100 (M) | 85-95 (M) | | | | | | | | |
| Welding Rods | Cyclones, ESP, Baghouse | Est Small (M) | Est Neg (M) | | | | | | | | |
| CONSUMPTIVE USE | | | | | | | | | | | |
| Installation of Asbestos Construction Material | None | 0 | 0 (3) | | | 61(0.97) | | | | | |
| Spray on Steel Fireproofing | Temporary Enclosures | Est 80-100 | Unk (3) | | | 15(0.24) | | | | | |
| Insulating Cement, Asbestos Type | Depends on Where Applied in System | (Est. 88% Net Control)(3) | | | | 25(0.40) | | | | | |
| Pesticides, Herbicides, Fungicides | None | 0 | 0 (M) | | 2925(32.72) | | | | 1800(18.99) | 500 lbs (0.01) | |
| Well Drilling Mud | None (Emissions .01% of Consumption) | 0 | 0 (M) | | | | 70(0.65) | | | | |
| Fertilizer Application | None | 0 | 0 (M) | | | | | | | | |
| Pharmaceuticals | None | 0 | 0 (M) | | | | | | | 910 lbs (0.02) | |

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) Sources of information for tabulat

(3) Underlined numbers in parentheses

TABLE I. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES - (CONT'D) (1)

| BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10.5(0.35) (3) | | | | | | | | | | | | | 1130(.75) |
| | | | | | 2(0.02) | | | | | | Unk | | | | |
| | | 3(0.10) | | | | | | | | | | | | | |
| | | | | 4200(34.98) | | | | | | | Unk | | | | |
| | | | | | | | 1250(13.47) | | | | 2170(0.05) | | | | |
| | | | | | | | 810(8.73) | | | | Unk | | | | |
| | | | | | | | Unk | | | | | | | | |
| | | | | | | | | 90(0.47) | | | | | | | |
| | | | | | | 5300(3.31) | | | | | | | | | |
| | | | | | | 280(0.18) | | | | | | | | | |
| | | | | | | 3780(2.36) | | | | | | | | | |
| | | | | | | 4970(3.10) | | | | | | | | | |
| | | | | | | 4080(2.55) | | | | | | | | | |
| 5.25(3.64) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | | | | | 270(0.17) | | | | | | | | | |
| | | | | | | Neg | | | | | | | | | |
| | | | 900(1.15) | | | | | | | | Unk | | | | |
| | | | | .5(Neg) | | | | | | | | | | | |
| | | | | .3(Neg) | | | | | | | | | | | |
| | | | | Neg | | | | | | | | | | | |
| 39 lbs(Neg) | | | | | | | | | 1(.13) | | | 1(0.12) | | | 10(0.01) |
| | 13(0.14) | | | | | | | | | | Unk | | | | |
| | | 400 lbs(0.01) | | | | | 2(0.02) | | | | | | | | |
| | | | | | | | | | | | | | Unk | | |
| | | 1128 lbs(0.02) | | | | | | | | | | | | | |
| | | | 1000(1.28) | | | | | | | | Unk | | | | |
| | | | | 7.3(0.06) | | | | | | | | | | | |
| | | | | | | 9720(6.07) | | | | | | | | | |
| | | | | | | | | | 2.6(.33) | | | | | | |
| | | | | | | | | | 3(.38) | | | | | | |
| | | | | | | | | | 1.2(.15) | | | | | | |
| | | | | | 230(1.71) | | | | | | | | | | |
| | | | | | | | | 24(0.13) | | | Unk | | | | |
| | | | | .1(Neg) | | | | | | | | | | | |
| | | | | Neg | | | | | | | | | | | |
| | | | | Neg | | | | | | | | | | | |
| | 1800(18.99) | 500 lbs (0.01) | | | | | Neg | | 19 (2.40) | | Unk | | | | |
| | | 910 lbs (0.02) | | | | | | | | | Unk | | | | |
| | | | | | | | | | 2.6(.33) | | | | | | |

(2) Sources of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

(3) Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE 1. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES - lbs/yr(1)

| INDUSTRY AND PROCESS | CONTROL DEVICES: TYPE OF C.D. | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORINE COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pulp and Paper | | | | | | | | | | | | | | | | | | | | | | | |
| Kraft Pulp Mill | | | | | | | | | | | | | | | | | | | | | | | |
| Recovery Furnace | ESP | 99 | 85-97 (43) | | | [illegible] | | | | | | | | | | | | | | | | | |
| " | Scrubber | | 60-95 (43) | | | | | | | | | 0.02(Neg) | | | | | | | | | | | |
| Lime Kiln | Venturi Scrubber | 95 | 95 (43) | | | | | | | | | | | | | | | | | | | | |
| Digester Relief & Blow Tank | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Dissolving Tank | Cyclonic Scrubber | 33 | 80 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Packed Tower | | 90 (43) | | | 15 | | | | | | | | | | | | | | | | | |
| " | Orifice Scrubber | | 91 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Mesh Pad | | 75 (43) | | | | | | | | | | | | | | | | | | | | |
| Sulfite Pulp Mill | | | | | | | | | | | | | | | | | | | | | | | |
| Recovery Furnace | ESP | 99 | 85-97 (43) | | | | | | | | | | | | | | | | | | | | |
| Digester Relief & Blow Tank | None | 0 | 0 (43) | | | | | | | | | | | | | | Neg | | Una | | | | |
| Neutral Sulfite Semichemical Pulping | | | | | | | | | | | | | | | | | | | | | | | |
| Recovery Furnace | ESP | 99 | 85-97 (43) | | | | | | | | | | | | | | | | | | | | |
| Blow Tank | None | 0 | 0 (43) | | | Neg | | | | | | Neg | | | | | | | | | | | |
| Absorption Tower | Secondary Scrubber | 33 | 75-98 (43) | | | | | | | | | | | | | | | | | | | | |
| Fluidized Bed Reactor | Cyclones | 100 | 70 (43) | | | | | | | | | | | | | | | | | | | | |
| Bleaching-All Processes | Chlorination Tower, Alkali Scrubber | 100 | 90-100(26) | | | | | | | | 16000(23.12) | | | | | | | | | | | | |
| Phosphate Fertilizer | | | | | | | | | | | | | | | | | | | | | | | |
| Pelletizing | Cyclones | 100 | 90 (43) | | | | | | | | | | | | | | | | | | | | |
| Granulation | Cyclones and/or Wet Scrubbers | 95 | 95 (43) | | | | | | | | | | | | | | | | | | | | |
| Material Handling | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | |
| Cotton Ginning (Arsenic) | Mostly Cyclones | 60 | 80 (4) | | 19(0.21) | | | | | | | | | | | | | | | | | | |
| Asphalt | | | | | | | | | | | | | | | | | | | | | | | |
| Paving Material | Cyclones | 5 | 72 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Cyclones Plus Various Devices | 95 \| 99 | 99 (43) | | | | | | | | | | | | | | | | 2800(0.28) | | | | |
| Roofing Material | | | | | | | | | | | | | | | | | | | | | | | |
| Blowing | Wet Scrubber and/or Afterburner | Est 99 (43) | | | | | | | | | | | | | | | | | | | | | |
| Saturation | Wet Scrubber and/or Low Power ESP | Est 99 (43) | 86 (43) | | | | | | | | | | | | | | | | 232.5(0.48)<br>Una | | | | |
| Ferro Alloys | | | | | | | | | | | | | | | | | | | | | | | |
| Blast Furnace | Chambers, Cyclones, Scrubbers, ESP | 100 | 99 (43) | | | | | | | | | | | | | 1113(5.86) | | 4918(8.22) | | | | | 1300(1.4) |
| Electric Furnace | Hood, Cyclones, Scrubbers, ESP, Baghouse | 50 | 81 (43) | | | | | | | | | | | | | 26644(9.12) | | 98(1.64) | Una | | | 113(2.94) | 50(1.11) |
| Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | | | | | | | | | | | | | | Neg | | | | 29(1.11) | Neg |
| Non-Ferrous Alloys | | | | | | | | | | | | | | | | | | | | | | | |
| Furnaces | Hood, ESP, Baghouse | 50 | Est 85-95(43) | | Neg | | | See 86 Alloys | * | 4.5(0.08) | | | | | | 90(0.32) | | 64(1.07) | Una | | | 3(0.02) | |
| Material Handling | Hood, Chamber, Cyclone, ESP, Baghouse | 35 | 90 (43) | | Neg | | | | | Neg | | | | | | Neg | | Neg | | | | Neg | |
| Silicomanganese (Electric Furnace) | Est. Cyclones, Scrubbers, ESP, Baghouse | Est Small | ~60 (8) | | | | | | | | | | | | | 41604(21.91) | | | Una | | | | |
| Phosphoric Acid | | | | | | | | | | | | | | | | | | | | | | | |
| Wet and Thermal Processes | Venturi Scrubber | 100 | 99.9 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Packed or Open Tower Scrubbers | | 50-98 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Glass-Fiber Mist Eliminators | | 99.9 (43) | | Neg | | | | | | | | | 4832(0.75) | | | | | | | | | |
| " | High Energy Wire-Mesh Contactors | | >99.9 (43) | | | | | | | | | | | | | | | | | | | | |
| " | ESP | | 95-99.9 (43) | | | | | | | | | | | | | | | | | | | | |
| Hydrofluoric Acid | | | | | | | | | | | | | | | | | | | | | | | |
| Vents | Scrubbers | Est 100 | Est 90-95(10) | | | | | | | | | | | 500(0.11) | | | | | | | | | |
| Kilns | Scrubbers | Est 100 | Est 90-95(10) | | | | | | | | | | | 200(0.12) | | | | | | | | | |
| Hydrofluoric Acid Alkylation | Alumina Packed Tower, Lime Pit | Est 100 | 17 (10) | | | | | | | | | | | 18000(3.92) | | | | | | | | | |
| Chlorine | | | | | | | | | | | | | | | | | | | | | | | |
| Manufacture | Return Vents and Alkali Scrubbers | Est 100 | 95-100 (26) | | | | | | | | 4000(5.11) | | | | | | | | | | | | |
| Liquefaction and Handling | " " " " " | Est 100 | 95-100 (26) | | | | | | | | 43000(54.99) | | | | | | | | Una | | | | |
| Organic Chlorine Chemicals | " " " " " | Est 100 | 95-100 (26) | | | | | | | | 8500(10.87) | | | | | | 76.2(8.96) | | | | | | |
| Hydrochloric Acid Manufacture | " " " " " | Est 100 | 95-100 (26) | | | | | | | | 800(1.02) | | | | | | | | | | | | |
| Glass Manufacture (General) | Wet Cl[illegible] | Una | Una | | 838(7.34) | | 60(1.17) | | | | | | | | 1800(12.55) | | | | | | | | |
| Frit Production | Baghouse, Venturi Scrubbers | | .10 | | Una | | | | | | | | | 700(0.44) | | | | | | 203(3.74) | | | |
| Wood Preservation | None | 0 | 0 | | Neg | | | | | | | | | | | | | | | | | | |
| Zinc Galvanizing | Same as Primary Zinc | Est 100 | 85-95 (8) | | | | | | | | | | | | | | | | | | | | |
| Misc. Arsenic Chemicals | Various | Una | Una | | 3.3(0.03) | | | | | | | | | | | | | | | | | | 45(1.91) |
| Barium Milling and Handling | Water Sprays, Cyclones, Baghouse | Est 100 | Est ~98 (8) | | | | 1700(24.74) | | | | | | | | | | | | | | | | |
| Barium Chemicals | Hoods, Cyclones, Chambers | Est 100 | Est 96 (8) | | | | 8600(10.64) | | | | | | | | | | | | | | | | |
| Vanadium Chemicals | Cyclones, ESP, Baghouse | Est 80-100 | Est 80-95(8) | | | | | | | | | | | | | | | | | | | | |
| Boron Chemicals | Cyclones, Scrubbers, Baghouse, ESP | 100 (10) | Una (8) | | | | | | 2400(21.22) | | | | | | | | | | | | | 4(1.27) | |
| Manganese Chemicals | Cyclones, ESP, Baghouse | Est. Small | Est Neg (8) | | | | | | | | | | | | | 300(1.55) | | | | | | | |
| Ceramic Coatings | Hood, Cyclone, Scrubber, Baghouse | 100 | Una (8) | | | | | Neg | 470(4.96) | | | | | | | | | | | | | Neg | |

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) Sources of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

(3) Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE I. MAGNITUDE OF HAZARDOUS

| INDUSTRY AND PROCESS | CONTROL DEVICES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING AND RAW MATERIAL PREPARATION | TYPE IN U.S. | % APPLICATION | % EFFICIENCY | EFFICIENCY OF FLUORIDE COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLORINE |
| Pulp and Paper | | | | | | | | | | | |
| Kraft Pulp Mill | | | | | | | | | | | |
| Recovery Furnace | ESP | 99 | 85-97 (43) | | | 15(0.24)(3) | | | | | |
| " | Scrubber | | 60-95 (43) | | | | | | | | |
| Lime Kiln | Venturi Scrubber | 99 | 95 (43) | | | | | | | | |
| Digester Relief & Blow Tank | None | 0 | 0 (43) | | | | | | | | |
| Dissolving Tank | Cyclonic Scrubber | 33 | 80 (43) | | | 15 | | | | | |
| " | Packed Tower | | 90 (43) | | | | | | | | |
| " | Orifice Scrubber | | 97 (43) | | | | | | | | |
| " | Mesh Pad | | 75 (43) | | | | | | | | |
| Sulfite Pulp Mill | | | | | | | | | | | |
| Recovery Furnace | ESP | 99 | 85-97 (43) | | | Neg | | | | | |
| Digester Relief & Blow Tank | None | 0 | 0 (43) | | | | | | | | |
| Neutral Sulfite Semichemical Pulping | | | | | | | | | | | |
| Recovery Furnace | ESP | 99 | 85-97 (43) | | | | | | | | |
| Blow Tank | None | 0 | 0 (43) | | | | | | | | |
| Absorption Tower | Secondary Scrubber | 33 | 74-98 (43) | | | | | | | | |
| Fluidized Bed Reactor | Cyclones | 100 | 70 (43) | | | | | | | | |
| Bleaching-All Processes | Chlorination Tower, Alkali Scrubber | 100 | 90-100(24) | | | | | | | | 18000(23.02) |
| Phosphate Fertilizer | | | | | | | | | | | |
| Pulverizing | Cyclones | 100 | 80 (43) | | | | | | | | |
| Granulation | Cyclones and/or Wet Scrubbers | 95 | 95 (43) | | | | | | | | |
| Material Handling | None | 0 | 0 (43) | | | | | | | | |
| Cotton Ginning (Arsenic) | Mostly Cyclones | 40 | 80 (4 | | 19(0.21) | | | | | | |
| Asphalt | | | | | | | | | | | |
| Paving Material | Cyclones | 5 99 | 70 (43) | | | | | | | | |
| " | Cyclones Plus Various Devices | 94 | 99 (43) | | | | | | | | |
| Roofing Material | | | | | | | | | | | |
| Blowing | Wet Scrubber and/or After Burner | Est 99 (43) | | | | | | | | | |
| Saturation | Wet Scrubber and/or Low Power ESP | Est 99 (43) | 86 (43) | | | | | | | | |
| Ferro Alloys | | | | | | | | | | | |
| Blast Furnace | Chambers, Cyclones, Scrubbers, ESP | 100 | 99 (43) | | | | | | | | |
| Electric Furnace | Hood, Cyclones, Scrubbers, ESP, Baghouse | 50 | 81 (43) | | | | | | | | |
| Material Handling | Hood, Chambers, Cyclones, ESP, Baghouse | 35 | 90 (43) | | | | | | | | |
| Non-Ferrous Alloys | | | | | | | | | | | |
| Furnaces | Hood, ESP, Baghouse | 50 | Est 80-90(43) | | Neg | | | See BE Alloys | | 2.5(0.08) | |
| Material Handling | Hood, Chamber, Cyclone, ESP, Baghouse | 35 | 90 (43) | | Neg | | | | | | |
| Silicomanganese (Electric Furnace) | Est. Cyclones, Scrubbers, ESP, Baghouse | Est Small | ~80 (M) | | | | | | | Neg | |
| Phosphoric Acid | | | | | | | | | | | |
| Wet and Thermal Processes | Venturi Scrubber | 100 | 99.9 (43) | | Neg | | | | | | |
| " | Packed or Open Tower Scrubbers | | 40-98 (43) | | | | | | | | |
| " | Glass-Fiber Mist Eliminators | | 99.9 (43) | | | | | | | | |
| " | High Energy Wire-Mesh Contactors | | >99.9 (43) | | | | | | | | |
| " | ESP | | 96-99.9 (43) | | | | | | | | |
| Hydrofluoric Acid | | | | | | | | | | | |
| Vents | Scrubbers | Est 100 | Est 90-95(50) | | | | | | | | |
| Kilns | Scrubbers | Est 100 | Est 90-95(50) | | | | | | | | |
| Hydrofluoric Acid Alkylation | Alumina Packed Tower, Lime Pit | Est 100 | 17 (50) | | | | | | | | |
| Chlorine | | | | | | | | | | | |
| Manufacture | Return Vents and Alkali Scrubbers | Est 100 | 95-100 (24) | | | | | | | | 4000(5.12) |
| Liquification and Handling | " " " " " | Est 100 | 95-100 (24) | | | | | | | | 43000(54.99) |
| Organic Chlorine Chemicals | " " " " " | Est 100 | 95-100 (24) | | | | | | | | 8500(10.87) |
| Hydrochloric Acid Manufacture | " " " " " | Est 100 | 95-100 (24) | | | | | | | | 800(1.02) |
| Glass Manufacture (General) | Wet Cyclone | Unk | Unk | | 638(7.14) | | 40(0.37) | | 1000(10.55) | | |
| Frit Production | Baghouse, Venturi Scrubbers | | 16 | | Unk | | | | | | |
| Wood Preservatives | None | 0 | 0 | | Neg | | | | | | |
| Zinc Galvanizing | Same as Primary Zinc | Est 100 | 85-95 (M) | | | | | | | | |
| Misc. Arsenic Chemicals | Various | Unk | Unk | | 3.3(0.04) | | | | | | |
| Barium Milling and Handling | Water Sprays, Cyclones, Baghouse | Est 100 | Est >99 (M) | | | | 2700(24.94) | | | | |
| Barium Chemicals | Hoods, Cyclones, Chambers | Est 100 | Est 96 (M) | | | | 4400(40.64) | | | | |
| Vanadium Chemicals | Cyclones, ESP, Baghouse | Est 80-100 | Est 80-95(M) | | | | | | | | |
| Boron Chemicals | Cyclones, Scrubbers, Baghouse, ESP | 100 (10) | Unk (M) | | | | | | 2400(25.32) | | |
| Manganese Chemicals | Cyclones, ESP, Baghouse | Est Small | Est Neg (M) | | | | | | | | |
| Ceramic Coatings | Hood, Cyclone, Scrubber, Baghouse | 100 | Unk (M) | | | | | Neg | 470(4.96) | | |

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) Sources of information for tabulated data

(3) Underlined numbers in parentheses show

TABLE 1. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES - (CONT'D)(1)

| BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.02(Neg) | | | | | | | | | | | |
| | | | | | | | | | Neg | | Unk | | | | |
| | | | | Neg | | | | | | | | | | | |
| | | | 18000(23.02) | | | | | | | | | | | | |
| | | | | | | | | | | | 2800(0.06) | | | | |
| | | | | | | | | | | | 23230(0.48) | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | | | | | | | 1113(5.86) | | 491(8.20) | Unk | | | | |
| | | | | | | | | | | | | | | | 2500(1.66) |
| | | | | | | | | 3669(19.32) | | 98(1.64) | | | | 115(0.64) | 500(.33) |
| | | | | | | | | | | Neg | | | | | |
| | | | | | | | | | | | | | | 29(0.16) | Neg |
| ee BE<br>lloys | | 2.5(0.08) | | | | | | 60(0.32) | | 64(1.07) | Unk | | | 3(0.02) | |
| | | Neg | | | | | | Neg | | Neg | | | | Neg | |
| | | | | | | | | 4164(21.92) | | | Unk | | | | |
| | | | | | | 6830(4.26) | | | | | | | | | |
| | | | | | | 500(0.31) | | | | | | | | | |
| | | | | | | 200(0.13) | | | | | | | | | |
| | | | | | | 5800(3.62) | | | | | | | | | |
| | | | 4000(5.12) | | | | | | | | Unk | | | | |
| | | | 43000(54.99) | | | | | | | | | | | | |
| | | | 8500(10.87) | | | | | | 70.2(8.86) | | | | | | |
| | | | 800(1.02) | | | | | | | | | | | | |
| | 1000(10.55) | | | | | | | | | | | | | | |
| | | | | | | | | | | | | 203(23.74) | | | |
| | | | | | | 700(0.44) | | | | | | | | | |
| | | | | | | | | | | | | | | | 950(.63) |
| | | | | | | | | | | | | | | 4(0.02) | |
| | 2400(25.32) | | | | | | | | | | | | | | |
| | | | | | | | | 300(1.58) | | | | | | | |
| eg | 470(4.96) | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | Neg | |

(2) Sources of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

(3) Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE I. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES --(CONT'D) (1)

| INDUSTRY AND PROCESS<br>METALS AND RAW MATERIAL PREPARATION | CONTROL DEVICES<br>TYPE IN USE | %<br>APPLICATION | %<br>EFFICIENCY | EFFICIENCY OF HCL COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] Chlorine Secondary Al, Mg, Cu, Pb, Zn | Alkali Scrubbers | 100 | 95-100 (26) | | | | | | | | 200(0.2) | | | | | | | | Una | (P(e)) | (P(e)) | (8) | (P(e)) |
| Primary Mercury | Assumed Similar to Primary Copper | Est 100 | 85-95 (M) | | | | | | | | | | | | | | 55(6.94) | | Una | | | | |
| Primary Copper | | | | | | | | | | | | | | | | | | | | | | | |
| Roasting | Settling, Water Spray and ESP | 100 | 85 (43) | | 900(10.27) | | | | | 229(7.58) | | | 2900(21.56) | 200(0.13) | 127(1.37) | | | | Una | 27(1.99) | | | |
| Reverberatory Furnaces | ESP | 60-85 | 95 (43) | | 400(4.48) | | | | | 9(3.12) | | | 1243(9.23) | 86(0.05) | 58(0.58) | | | | | 8(0.94) | | | |
| Converters | Settling Plus Cyclones or ESP | 85 | 95 (43) | | 1150(12.87) | | | | | 270(8.95) | | | 3329(27.70) | 257(0.16) | 163(1.76) | | | | | 22(2.17) | | | |
| Material Handling | Hood, Chamber, Cyclone, ESP or Baghouse | 35 | 90 (43) | | 250(2.80) | | | | | 59(1.96) | | | 828(6.15) | 57(0.04) | 36(0.39) | | | | | 5(0.59) | | | |
| Primary Manganese | Assumed Similar to Primary Copper | 80-100 | 85-95 (M) | | | | | | | | | | | | | 125(1.71) | | | Una | | | | |
| Primary Zinc | | | | | | | | | | | | | | | | | | | | | | | |
| Roasting | | | | | | | | | | | | | | | | | | | | | | | |
| Fluid Bed | Waste Heat Boiler Plus Cyclone Plus ESP | 100 | 98 (43) | | 1390(15.55) | | | | | 86(27.07) | | | | 127(0.08) | 159(1.71) | | | | Una | 27(3.16) | | | [illegible] |
| Susp and Multihearth | " | 100 | 85 (43) | | | | | | | | | | | | | | | | | | | | |
| Sintering | ESP, Baghouse, or Scrubber / Plus Mist Wells ESP | 100 | 95 (43) | | | | | | | 26(7.42) | | | | 55(0.03) | 68(0.73) | | | | | | | | |
| Distillation | None (Intentional by Industry) | 0 | 0 (43) | | Una | | | | | | | | | | | | | | | | | | |
| Material Handling | Hood, Chamber, Cyclone or Baghouse | 35 | 90 (43) | | | | | | | 9(2.98) | | | | 18(0.01) | 23(0.25) | | | | | | | | [illegible] |
| Primary Nickel | Assumed Similar to Primary Copper | 80-100 | 85-95 (M) | | | | | | | Neg | | | | | | | | | | | | | [illegible] |
| Primary Lead | | | | | | | | | | Neg | | | | | | | | | | | | | [illegible] |
| Sintering | Cyclone Plus Baghouse or ESP | 93 | 95 (43) | | | | | | | | | | | | 260(2.65) | | | | Una | | | | |
| Blast Furnace | " " " " | 95 (43) | 85 (M) | | 285(3.19) | | | | | 8(2.19) | | | | 150(0.09) | 510(5.49) | | | | | | | | |
| Dross Reverberatory Furnace | Waste Heat Boiler Plus Baghouse or ESP | Est 90-62 | 95 (43) | | 80(0.90) | | | | | 15(.41) | | | | 40(0.03) | 136(1.47) | | | | Una | 5(1.59) | | | |
| Material Handling | Hood, Chamber, Cyclone, ESP or Baghouse | 35 | 90 (43) | | 11(0.12) | | | | | 7(0.10) | | | | 10(0.01) | 69(0.73) | | | | | 2(0.23) | | | |
| [illegible] | Same as Primary Zinc | Est 100 (M) | 85-95 (43) | | Una | | | | | Neg | | | | | | | | | | | | | |
| Secondary Aluminum | | | | | | | | | | | | | | | | | | | | | | | 4,000(1.39) |
| Scrap Preparation | Hood Plus Settling Plus Baghouse | Una | 94 (43) | | | | | | | | | | | | | | | | | | | | |
| Smelting Furnace | Afterburner Plus Baghouse | Est 20 | 95 (43) | | | | | | | | | | | | | | | | | | | | |
| Refining Furnace Hood | Hood Plus Baghouse | 80 | 95 (43) | | | | | | | | | | | | | | | | | | | | |
| Chlorine Fluxing | Plus Scrubber-Caustic Solution | Una | 50-60 (43) | 95-99 (43) | | | | | | See Primary (neg) Aluminum | | | | | | | | | Una | | | | |
| Chlorine Fluxing | Packed Column-Caustic Solution | Una | 80-90 (43) | 50-60 (43) | | | | | | | | | | | | | | | Una | | | | |
| Secondary Copper (incl. Brass & Bronze) | | | | | | | | | | | | | | | | | | | | | | | |
| Scrap Preparation | None | 0 | 0 (43) | | | | | | | | | | 5(0.04) | | 0 | | | | | | | | |
| Wire Burning | None | 0 | 0 (43) | | | | | | | | | | 155(1.15) | | 390(4.20) | | | | | | | | |
| Smelting Furnaces | Afterburner Plus Baghouse | Est 25 | 95 (43) | | | | | | | 70(2.32) | | | 15(.11) | | 42(0.45) | | | | | | | | |
| Blast Furnace | Baghouse (Rarely Scrubber) | 75 | 92 (43) | | | | | | | 53(1.87) | | | 45(.33) | | 42(0.45) | | | | Una | 4(0.47) (Includes all smelters) | Una | | 12(1.?) |
| Smelting and Refining | | | | | | | | | | | | | | | | | | | | | | | |
| Reverberatory | Hood Plus Baghouse | 71 | 95 (43) | | | | | | | | | | 15(.11) | | 62(0.67) | | | | | | | | [illegible] |
| Rotary | Hood Plus Baghouse | 60 | 95 (43) | | | | | | | | | | 5(.04) | | 6(0.06) | | | | | | | | [illegible] |
| Secondary Zinc | | | | | | | | | | | | | | | | | | | | | | | [illegible] |
| Scrap Preparation | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | [illegible] |
| Sweating Furnaces | Afterburner Plus Baghouse | Est 20 | 95 (43) | | | | | | | | | | | | | | | | Una | | | | |
| Distillation Furnaces | Product-Collecting Exhaust Plus Baghouse | 100 | 95 (43) | | | | | | | | | | | | | | | | | | | | |
| Secondary Lead | | | | | | | | | | | | | | | | | | | | | | | [illegible] |
| Scrap Preparation | None | 0 | 0 (43) | | | | | | | | | | | | | | | | | | | | [illegible] |
| Smelting Furnaces | | | | | | | | | | | | | | | Neg | | | | | | | | |
| Blast | Baghouse or Baghouse Plus ESP | 95-100 | 93 (43) | | | | | | | | | | | | | | | | | | | | |
| Reverberatory | Baghouse or Baghouse Plus ESP | 95-100 | 93 (43) | | | | | | | | | | | | | | | | | | | | |
| Pot Refining | Hood Plus Baghouse | 95 | 95 (43) | | | | | | | | | | | | 1500(16.16) | | | | Una | | | | |
| Battery Process (Lead Oxide) | Settling Plus Baghouse Plus Screw Conveyor | 100 | 85-99 (43) | | | | | | | | | | | | 500(5.39) | | | | | | | | |
| Secondary Mercury | Assumed Same as Primary Copper | Est 100 | 85-95 (M) | | | | | | | | | | | | Neg | | 11(1.39) | | | | | | |
| Secondary Manganese | | | | | | | | | | | | | | | 20(0.22) | | | | Una | | | | |
| [illegible] Oil and [illegible] Plant | None | 0 | 0 (8) | | | | | | | | | | | | | | | | Una | | | | |
| [illegible] Refining | Assumed Same as Primary Copper | 80-100 | 85-95 (M) | | | | | | | | | | | | | | | | Una | | | | |
| Iron and Steel | | | | | | | | | | | | | | | | | | | | | | | |
| Sintering | Cyclones | 61 | 90 (43) | | | | | | | | | | | | | | | | Una | | | 81(2.43) | |
| " | Cyclones and ESP | 36 | 90 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Baghouse | 19 | 90 (43) | | | | | | | | | | | 18200(11.38) | | | | | Una | | | | |
| Metallurgical Coke | None | 0 | 0 (43) | | | | Una | | | | | | | | | | | | | | | | |
| Blast Furnace | Settling Chambers, Cyclones, ESP | 100 | 99 (43) | | | | 1221(1.06) | | | 1000(33.14) | | | 1270(7.95) | 2800(1.75) | | 1000(5.17) | | | ≤1380(1.90) | | | [illegible] | [illegible] |
| Open Hearth | ESP | 41 | 97 (43) | | | | 80(1.35) | | | | | | 1510(11.51) | 25600(13.83) | 150(1.62) | 1460(8.76) | | 100(1.87) | Una | | 260(7.01) | [illegible] | [illegible] |
| Basic Oxygen Furnace | ESP | 51 | | | | | 20(1.04) | | | | | | 70(.52) | | | 1260(5.18) | | | | | | [illegible] | [illegible] |
| " | High Energy Venturi Scrubber | 49 | 99 (43) | | | | 30(0.33) | | | | | | 70(.52) | | | 620(2.78) | | | | | | | |
| Electric Arc Furnace | Baghouse (Rarely Scrubber or ESP) | 100 | 99 (43) | | | | | | | | | | | | | | | | | | | Neg | [illegible] |
| [illegible] Fluxing | Alkali Scrubbers | 100 | 99-100 (43) | | | | | | | | 1600(7.41) | | | | | | | | Una | | | | |
| Gray Iron Foundries | | | | | | | | | | | | | | | | | | | | | | | |
| Cupola | ESP | Neg | 97 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Cyclones | 5 | 75 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Baghouse | 2 / 13 | 99 (43) | | 87(1.09) | | 50(7.46) | 4(2.77) | | | | | 50(.37) | | 1400(15.06) | 1270(14.54) | | 74(1.32) | | | | [illegible] | [illegible] |
| " | Wet Scrubber | 18 | 95 (43) | | | | | | | | | | | | | | | | | | | | |
| " | Wet Cap | 1 | 50 (43) | | | | | | | | | | | | | | | | | | | | |
| Core and Limestone Handling | Hood and Cyclone | 15 | 80 (43) | | | | | | | | | | | | | | | | | | | | |
| Sand Handling and Operations | Wet & Fixed [illegible] Cyclone or Baghouse | Est 25 | 99 (43) | | | | | | | | | | | | | | | | | | | | |

(3) Source: The [illegible] Corporation
Preliminary Results
EPA Contract No. 68-01-[illegible]

(1) Sources of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

(2) Underlined numbers in parentheses show percentage of all emissions of that pollutant from that source.

TABLE I. MAGNITUDE OF HAZAR

| INDUSTRY AND PROCESS | CONTROL DEVICES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MINING AND RAW MATERIAL PREPARATION | TYPE IN USE | % APPLICATION | % EFFICIENCY | EFFICIENCY OF HCL COLLECTION | ARSENIC | ASBESTOS | BARIUM | BERYLLIUM | BORON | CADMIUM | CHLORINE |
| Chlorine Fluxing (Includes Secondary Al, All Cu, Pb, Zn) | Alkali Scrubbers | 100 | 95-100 (24) | | | | | | | | 100(0.13) |
| Primary Mercury | Assumed Similar to Primary Copper | Est 100 | 85-95 (M) | | | | | | | | |
| Primary Copper | | | | | | | | | | | |
| Roasting | Settling, Water Spray and ESP | 100 | 85 (43) | | 900(10.07) | | | | | 229(7.59) | |
| Reverberatory Furnaces | ESP | 80-85 | 95 (43) | | 400(4.48) | | | | | 94(3.12) | |
| Converters | Settling Plus Cyclones or ESP | 85 | 95 (43) | | 1150(12.8) | | | | | 270(8.95) | |
| Material Handling | Hood, Chamber, Cyclone, ESP or Baghouse | 35 | 90 (43) | | 250(2.80) | | | | | 59(1.96) | |
| Primary Manganese | Assumed Similar to Primary Copper | 80-100 | 85-95 (M) | | | | | | | | |
| Primary Zinc | | | | | | | | | | | |
| Roasting | | | | | | | | | | | |
| Fluid Bed | Waste Heat Boiler Plus Cyclone Plus ESP | 100 | 98 (43) | | 1390(15.55) | | | | | 666(22.07) | |
| Ropp and Multihearth | " | 100 | 85 (43) | | | | | | | | |
| Sintering | ESP, Baghouse, or Scrubber Plus Moist Horiz. ESP | 100 | 95 (43) | | Unk | | | | | 284(9.41) | |
| Distillation | None (Intentional by Industry) | 0 | 0 (43) | | | | | | | 90(2.98) | |
| Material Handling | Hood, Chamber, Cyclone or Baghouse | 35 | 90 (43) | | | | | | | Neg | |
| Primary Nickel | Assumed Similar to Primary Copper | 80-100 | 85-95 (M) | | | | | | | Neg | |
| Primary Lead | | | | | | | | | | | |
| Sintering | Cyclone Plus Baghouse or ESP | 90 | 95 (43) | | 285(3.19) | | | | | 66(2.19) | |
| Blast Furnace | " " " " " | 98 (43) | 85 (M) | | 80(0.90) | | | | | 19(.63) | |
| Dross Reverberatory Furnace | Waste Heat Boiler Plus Baghouse or EST | Est 50-60 | 95 (43) | | 11(0.12) | | | | | 3(0.10) | |
| Material Handling | Hood, Chamber, Cyclone, ESP or Baghouse | 35 | 90 (43) | | Unk | | | | | Neg | |
| Zinc Oxide | Same as Primary Zinc | Est 100 (M) | 85-95 (43) | | | | | | | | |
| Secondary Aluminum | | | | | | | | | | | |
| Scrap Preparation | Hood Plus Settling Plus Baghouse | Unk | 94 (43) | | | | | | | | |
| Sweating Furnace | Afterburner Plus Baghouse | Est 20 | 95 (43) | | | | | | | | |
| Refining Furnace Hood | Hood Plus Baghouse | 60 | 95 (43) | | | | | | | | |
| Chlorine Fluxing | Slot Scrubber-Caustic Solution | Unk | 50-60 (43) | 95-99 (43) | | | | | | See Primary(neg) Aluminum | |
| Chlorine Fluxing | Packed Column-Caustic Solution | Unk | 80-90 (43) | 50-60 (43) | | | | | | | |
| Secondary Copper (Incl. Brass & Bronze) | | | | | | | | | | | |
| Scrap Preparation | None | 0 | 0 (43) | | | | | | | | |
| Wire Burning | None | 0 | 0 (43) | | | | | | | | |
| Sweating Furnaces | Afterburner Plus Baghouse | Est 20 | 95 (43) | | | | | | | 70(2.32) | |
| Blast Furnace | Baghouse (Rarely Scrubber) | 75 | 90 (43) | | | | | | | 55(1.82) | |
| Smelting and Refining | | | | | | | | | | | |
| Reverberatory | Hood plus Baghouse | 71 | 95 (43) | | | | | | | | |
| Rotary | Hood Plus Baghouse | 80 | 95 (43) | | | | | | | | |
| Secondary Zinc | | | | | | | | | | | |
| Scrap Preparation | None | 0 | 0 (43) | | | | | | | | |
| Sweating Furnaces | Afterburner Plus Baghouse | Est 20 | 95 (43) | | | | | | | | |
| Distillation Furnaces | Product-Collecting Exhaust Plus Baghouse | 100 | 95 (43) | | | | | | | | |
| Secondary Lead | | | | | | | | | | | |
| Scrap Preparation | None | 0 | 0 (43) | | | | | | | | |
| Sweating Furnaces | | | | | | | | | | | |
| Blast | Baghouse or Baghouse Plus ESP | 95-100 | 95 (43) | | | | | | | | |
| Reverberatory | Baghouse or Baghouse Plus ESP | 95-100 | 95 (43) | | | | | | | | |
| Pot Refining | Hood Plus Baghouse | 95 | 95 (43) | | | | | | | | |
| Barton Process (Lead Oxide) | Ducting Plus Baghouse Plus Screw Conveyor | 100 | 95-99 (43) | | | | | | | | |
| Secondary Mercury | Assumed Same as Primary Copper | Est 100 | 85-95 (M) | | | | | | | | |
| Secondary Manganese | | | | | | | | | | | |
| Each Pot and Total Plant | None | 0 | 0 (6) | | | | | | | | |
| Vanadium Refining | Assumed Same as Primary Copper | 80-100 | 85-95 (M) | | | | | | | | |
| Iron and Steel | | | | | | | | | | | |
| Sintering | Cyclones | 45 | 90 (43) | | | | | | | | |
| " | Cyclones and ESP | 36 | 90 (43) | | | | | | | | |
| " | Baghouse | 19 | 90 (43) | | | | | | | | |
| Metallurgical Coke | None | 0 | 0 | | | | Unk | | | | |
| Blast Furnace | Settling Chambers, Cyclones, ESP | 100 | 99 (43) | | | | 112(1.04) | | | 1000(33.14) | |
| Open Hearth | ESP | 41 | 97 (43) | | | | 38(0.35) | | | | |
| Basic Oxygen Furnace | ESP | 61 | | | | | 20(0.19) | | | | |
| " | High Energy Venturi Scrubber | 39 100 | 99 (43) | | | | | | | | |
| Electric Arc Furnace | Baghouse (Ocnl. Scrubber or ESP) | 100 | 99 (43) | | | | 36(0.33) | | | | |
| Chlorine Fluxing | Alkali Scrubbers | 100 | 95-100 (43) | | | | | | | | 1900(2.43) |
| Gray Iron Foundary | | | | | | | | | | | |
| Cupola | ESP | Neg | 97 (43) | | 97(1.09) | | 50(0.46) | 4(2.27) | | | |
| " | Cyclones | 5 | 75 (43) | | | | | | | | |
| " | Baghouse | 3 33 | 99 (43) | | | | | | | | |
| " | Wet Scrubber | 18 | 90 (43) | | | | | | | | |
| " | Wet Cap | [illegible] | 50 (43) | | | | | | | | |
| Coke and Limestone Handling | Hood and Cyclone | 25 | 80 (43) | | | | | | | | |
| Sand Handling and Operations | Wet Scrubber (Ocnl. Cyclone or Baghouse) | Est 25 | 99 (43) | | | | | | | | |

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) Sources of information for tabulated data are indicate

(3) Underlined numbers in parentheses show percentage of

TABLE I. MAGNITUDE OF HAZARDOUS POLLUTANT EMISSIONS FROM SELECTED INDUSTRIAL SOURCES -(CONT'D) (1)

| BERYLLIUM | BORON | CADMIUM | CHLORINE | CHROMIUM | COPPER | FLUORIDES | LEAD | MANGANESE | MERCURY | NICKEL | POM | SELENIUM | TIN | VANADIUM | ZINC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 100(0.13)(37) | | | | | | | | | | | | |
| | | | | | | | | | | | *Unk* | (#12) (2) | (#56) | (#8) | (#13) |
| | | | | | | | | | 55(6.94) | | Unk | | | | |
| | | 229(7.59) | | | 2900(21.56) | 200(0.13) | 127(1.37) | | | | | | | | |
| | | 94(3.12) | | | 1243(9.23) | 86(0.05) | 54(0.58) | | | | | 17(1.99) | | | |
| | | 270(8.95) | | | 3729(27.70) | 257(0.16) | 163(1.76) | | | | Unk | 8(0.94) | | | |
| | | 59(1.96) | | | 828(6.15) | 57(0.04) | 36(0.39) | | | | | 22(2.57) | | | |
| | | | | | | | | | | | | 5(0.59) | | | |
| | | | | | | | | 325(1.71) | | | Unk | | | | |
| | | 666(22.07) | | | | 127(0.08) | 159(1.71) | | | | | | | | |
| | | 284(9.41) | | | | | | | | | Unk | 27(3.16) | | | 31818 (21.13) |
| | | | | | | 55(0.03) | 68(0.73) | | | | | | | | |
| | | 90(2.98) | | | | 18(0.01) | 23(0.25) | | | | | | | | 13637 (9.05) |
| | | Neg | | | | | | | | | | | | | |
| | | Neg | | | | | | | | | | | | | 4545(3.02) |
| | | | | | | | 246(2.65) | | | | | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | 66(2.19) | | | | 150(0.09) | 510(5.49) | | | | | | | | |
| | | 19(.63) | | | | 40(0.03) | 136(1.47) | | | | | 5(0.59) | | | |
| | | 3(0.10) | | | | 10(0.01) | 68(0.73) | | | | Unk | 2(0.23) | | | |
| | | Neg | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | 8100(5.38) |
| | | | | | | | | | | | Unk | | | | |
| | | See Primary(neg) Aluminum | | | | | | | | | | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | | | | 5(0.04) | | 0 | | | | | | | | |
| | | | | | 155(1.15) | | 390(4.20) | | | | | | | | |
| | | 70(2.32) | | | 15(.11) | | 42(0.45) | | | | | | | | |
| | | 55(1.82) | | | 15(.11) | | 42(0.45) | | | | | 1(0.12)<br>includes<br>all<br>smelters) | | | 135(0.09) |
| | | | | | | | | | | | Unk | | Unk | | 14(0.01) |
| | | | | | 15(.11) | | 42(0.45) | | | | | | | | 14(0.01) |
| | | | | | 5(.04) | | 4(0.04) | | | | | | | | |
| | | | | | | | | | | | | | | | 14(0.01) |
| | | | | | | | | | | | | | | | 3(Neg) |
| | | | | | | | | | | | Unk | | | | |
| | | | | | | | | | | | | | | | 2890(1.92) |
| | | | | | | | Neg | | | | | | | | 950(.63) |
| | | | | | | | 1500(16.16) | | | | Unk | | | | |
| | | | | | | | 500(5.39) | | | | | | | | |
| | | | | | | | Neg | | | | | | | | |
| | | | | | | | 20(0.22) | | | | | | | | |
| | | | | | | | | | 11(1.39) | | Unk | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | | | | | | | | | | | | | 81(0.45) | |
| | | | | | | 18200(11.36) | | | | | | | | | |
| | | | | | | | | | | | Unk | | | | |
| | | | | | | | | | | | 43380(0.90) | | | | |
| | | 1000(33.14) | | | 1070(7.95) | 2800(1.75) | | 1000(5.27) | | | | | | | |
| | | | | | 1550(11.51) | 25400(15.85) | 150(1.62) | 1660(8.74) | | 100(1.67) | | | | 63(0.35) | 1070(0.71) |
| | | | | | | | | | | | Unk | | 260(7[illegible].03) | 166(0.93) | 39000(25.89) |
| | | | | | 70 (.52) | | | 1060(5.58) | | | | | | | |
| | | | | | 70 (.52) | | | | | | | | | 7(0.04) | 900(0.60) |
| | | | | | | | | 620(3.26) | | | | | | | |
| | | | 1900(2.43) | | | | | | | | | | | | |
| | | | | | | | | | | | Unk | | | Neg | 3400(4.91) |
| 77) | | | | | 50(.37) | | 1400(15.08) | 2270(14.58) | | 79(1.32) | | | | 1(0.01) | 700(1.13) |

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of information for tabulated data are indicated by numbers in parentheses which refer to Bibliography in Section VI.

d numbers in parentheses show percentage of all emissions of that pollutant from that source.

## TABLE 2

## SOURCE OF HAZARDOUS POLLUTANTS (1)

## ORDERING OF EMITTERS

## TOTAL TONNAGE OF ALL PRODUCTS

## BY OPERATION

| | SOURCE | TONS |
|---|---|---|
| 1. | Open Burning | 4,548,070 |
| 2. | Open Hearth Furnaces | 68,227 |
| 3. | Pulverized Coal Boiler, Power Plant | 51,471 |
| 4. | Oil Burners, Residential | 44,063 |
| 5. | Metallurgical Coke | 43,380 |
| 6. | Chlorine Liquefaction | 43,000 |
| 7. | Roasting, Non-Ferrous Metals | 38,560 |
| 8. | Incineration | 34,307 |
| 9. | Sintering, Non-Ferrous Metals | 33,620 |
| 10. | Ore Mining and Handling | 26,855 |
| 11. | Asphalt Roofing Materials | 23,330 |
| 12. | Gas Burners, Industrial | 20,220 |
| 13. | Pellet Plants, Iron Ore Preparation | 18,200 |
| 14. | Bleaching,Pulp and Paper | 18,000 |
| 15. | Oil Burners, Power Plants | 14,273 |
| 16. | Oil Burners, Industrial | 14,053 |
| 17. | Blast Furnace | 13,352 |
| 18. | Stoker Coal Boiler, Industrial | 13,237 |
| 19. | Electric Furnace | 12,508 |
| 20. | Gas Burners, Residential/Commercial | 10,065 |
| 21. | Structural Clay Products | 9,720 |
| 22. | Superphosphate Manufacture | 8,980 |
| 23. | Prebake, Aluminum Ore Reduction | 8,610 |
| 24. | Organic Chemicals | 8,570 |
| 25. | Zinc Oxide Manufacture | 8,100 |
| 26. | Reduction, Aluminum | 7,620 |
| 27. | Phosphoric Acid, Wet & Thermal Processes | 6,830 |
| 28. | Gas Burner, Power Plant | 6,151 |
| 29. | Cupola, Gray Iron Foundry | 6,151 |
| 30. | Stoker Coal Boiler, Power Plant | 5,994 |
| 31. | Hydrofluoric Acid Alkylation | 5,800 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

| | | |
|---|---|---|
| 32. | Distillation, Primary Zinc | 5,626 |
| 33. | Converters, Primary Copper | 5,591 |
| 34. | Expanded Clay Aggregate | 5,300 |
| 35. | Use of Pesticides, Herbicides, Fungicides | 4,744 |
| 36. | Barium Chemicals | 4,400 |
| 37. | Primary Chromium | 4,200 |
| 38. | Electrothermal Phosphorous | 4,080 |
| 39. | Chlorine Manufacture | 4,000 |
| 40. | Pulverized Coal Boiler, Industrial | 3,783 |
| 41. | Petroleum Refining | 3,420 |
| 42. | Sweating Furnace, Secondary Non-Ferrous Metals | 3,031 |
| 43. | Asphalt Paving Material | 2,800 |
| 44. | Barium Milling & Handling | 2,700 |
| 45. | Reverberatory Furnace | 2,548 |
| 46. | Boron Chemicals | 2,400 |
| 47. | Basic Oxygen Furnace | 2,057 |
| 48. | Fluxing Chlorine | 2,000 |
| 49. | Cyclone Coal Boiler, Industrial | 1,891 |
| 50. | Glass Manufacture | 1,881 |
| 51. | Cyclone Coal Boiler, Power Plant | 1,776 |
| 52. | Defluorination of Phosphate Rock | 1,760 |
| 53. | Material Handling, Manufacture | 1,264 |
| 54. | Zinc Chemicals | 1,130 |
| 55. | Miscellaneous Chlorine Products | 1,000 |
| 56. | Zinc Galvanizing | 950 |
| 57. | Chlorine Bleach Manufacture | 900 |
| 58. | Lead Alkalyd Chemicals | 810 |
| 59. | Hydrochloric Acid Manufacture | 800 |
| 60. | Frit Production, Glass Manufacturing | 700 |
| 61. | Wire Burning, Secondary Copper | 681 |
| 62. | Residential/Commercial Coal Boilers | 657 |
| 63. | Hydrofluoric Acid Vents | 500 |
| 64. | Manganese Chemicals | 470 |
| 65. | Ceramic Coatings | 470 |
| 66. | Primary Manganese | 325 |
| 67. | Brake Lining Manufacture | 312 |
| 68. | Cement Kilns | 270 |
| 69. | Primary Nickel | 246 |
| 70. | Miscellaneous Copper Products Manufacture | 230 |
| 71. | Application of Paint | 215 |
| 72. | Shingle & Siding Manufacture | 205 |
| 73. | Hydrofluoric Acid Kilns | 200 |
| 74. | Pesticide Manufacture | 197 |
| 75. | Dry Storage Batteries | 90 |
| 76. | Vanadium Refining | 81 |
| 77. | Well Drilling Mud | 70 |
| 78. | Installation of Asbestos Materials | 61 |

| | | |
|---|---|---|
| 79. | Primary Mercury | 55 |
| 80. | Laboratory Use of Mercury | 51 |
| 81. | Paint Manufacture | 42 |
| 82. | Use of Insulating Cement | 25 |
| 83. | Welding Rods Consumption | 23 |
| 84. | Barton Process, Secondary Lead | 20 |
| 85. | Cotton Ginning | 19 |
| 86. | Asbestos Textiles | 18 |
| 87. | Recovery Furnace, Pulp and Paper | 15 |
| 88. | Spray-on Fire Proofing | 15 |
| 89. | Soap & Detergent Manufacture | 13 |
| 90. | Rotary Furnace | 12 |
| 91. | Secondary Mercury | 11 |
| 92. | Cadmium Paint Pigments | 11 |
| 93. | Refractory Bricks | 7 |
| 94. | Scrap Metal Preparation - Secondary Non-Ferrous Metal | 5 |
| 95. | Beryllium Alloys and Compounds | 5 |
| 96. | Vanadium Chemicals | 4 |
| 97. | Cadmium-Barium Stabilizers | 3 |
| 98. | Miscellaneous Arsenic Chemicals | 3 |
| 99. | Electrical Apparatus Manufacture | 3 |
| 100. | Miscellaneous Copper Metals & Alloys | 2 |
| 101. | Instrument Manufacture | 2 |
| 102. | Pharmaceuticals | 2 |
| 103. | Dental Apparatus | 1 |
| 104. | Cadmium-Nickel Batteries | NEG |
| 105. | Miscellaneous Cadmium Products | NEG |
| 106. | Fertilizer Application | NEG |

TABLE 3

NUMBER OF SOURCE LOCATIONS AND GENERAL EMISSION CHARACTERISTICS (1)

A. OPERATIONS CONTRIBUTING 90% OF HAZARDOUS POLLUTANTS

| OPERATION | INDUSTRY | NO. OF LOCATIONS | ADJACENT POPULATION (MILLION)(3) | POLLUTANT PROPERTIES | |
|---|---|---|---|---|---|
| | | | | PHYSICAL(2) | CHEMICAL |
| Pulverized Coal Boilers Power Plants | Power Plants | 325 | | P, $P_F$ | Inorganic/metal oxides Fluorides, Polyorganics As, Ba, Be, B, Cr, Cu, Pb, Mn, Hg, Ni, Se, Sn, V, Zn |
| | | | | Gas | Fluorides |
| Open Hearth Furnace | Iron & Steel (no oxygen lance) | 604 | | $P_F$ | Ba, Pb, Mn, Hg, Sn, V, Zn oxides, Fluorides, POM |
| | | | | Gas | Fluorides, HF |
| | (with oxygen lance) | | | $P_F$ | Ba, Pb, Mn, Mg, Sn, V, Zn oxides, POM |
| | | | | Gas | Fluorides, HF |
| Blast Furnace | Iron & Steel | 140 | | P, $P_F$, Gas | As, Cd, Mn, Hg, Ni, V, Zn oxides, Fluorides, POM |
| | Ferro-Alloys | 53 | 3.2 | P, $P_F$ | Mn, Ni, Zn oxides, POM |
| | Secondary Pb | 64 | 47.8 | P, $P_F$, Gas | As, Pb oxides, POM, Fluorides |
| | Primary Pb | 10 | 0.3 | P, $P_F$, Gas | As, Cd, Pb oxides, POM Fluorides |
| | Secondary Cu | 20 | 19.3 | P, $P_F$, Gas | As, Cd, Zn |
| Roasting | Primary Cu | 19 | 0.6 | P | Cu, POM, As, Cd, Fluorides, Pb, Se |
| | Primary Zn | 17 | 0.5 | P, $P_F$, Gas | Cd, Fluorides, Pb, POM Se, Zn |
| Small Boilers, Oil (Residential, Commercial) | Resident Fuel | 44000 | | $P_F$ | Ba, Be, Cr, Cu, Pb, Mn, Hg, Ni, POM, Se, Sn, V, Zn |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

(2) P - Particulates
$P_F$ - Fine Particulates

(3) Data show total population of large cities near to known sources.

TABLE 3

NUMBER OF SOURCE LOCATIONS AND GENERAL EMISSION CHARACTERISTICS

A. OPERATIONS CONTRIBUTING 90% OF HAZARDOUS POLLUTANTS

(Continued)

| OPERATION | INDUSTRY | NO. OF LOCATIONS | ADJACENT (3) POPULATION (MILLION) | POLLUTANT PROPERTIES PHYSICAL (2) | POLLUTANT PROPERTIES CHEMICAL |
|---|---|---|---|---|---|
| Ore Mining and Handling | Asbestos Mining | 9 | Neg | P | Asbestos, Cr |
| | Lead Mining | 25 | | P | As, Cd, Pb |
| | Copper Mining | 25 | | P | As, Cd, Cu, Pb |
| | Borax Mining | 4 | | P | B |
| | Barium Mining | 43 | | P | Ba |
| Open Burning | Agri Burning | | | $P, P_F$, Gas | As, POM |
| | Forest Fires | | | $P, P_F$, Gas | As, POM |
| | Open Burning | | | $P, P_F$, Gas | As, POM |
| | Conical Burner | | | $P_F$, Gas | POM |
| | Coal Refuse | | | $P, P_F$ | As, B, POM |
| Converters | Primary Cu | 19 | 0.6 | P | As, Cd, Cu, Fluoride, Pb, POM, Se |
| Large Boilers, Oil Power Plants | Power Plants | 115 | | $P_F$ | Inorganic/Metal Oxides, Polyorganics<br>Ba, Be, Cr, Cu, Pb, Mn, Hg, Ni, Se, V |
| Liquefaction | Chlorine MFG | 39 | | Gas | $C_2$, POM |
| Electric Furnace | Iron & Steel | 379 | | $P, P_F$ | Ba, Mn, Hg, Zn, |
| | Ferro-Alloys | 53 | 3.2 | $P, P_F$ | Mn, Ni, POM, V, Zn |
| | Silicomanganese | | | $P, P_F$ | Mn, POM |
| Pesticides, Herbicides, Fungicides, Consumption | Pesticides, etc., Use | | | $P, P_F$ | As, B, Cd, Hg, Pb, Inorganic & Organic Compounds, Polyorganics |

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(2) P - Particulates
$P_F$ - Fine Particulates

(3) Data show total Population of Large Cities near to known sources.

TABLE 3

NUMBER OF SOURCE LOCATIONS AND GENERAL EMISSION CHARACTERISTICS

A. OPERATIONS CONTRIBUTING 90% OF HAZARDOUS POLLUTANTS
(Continued)

| OPERATION | INDUSTRY | NO. OF LOCATIONS | ADJACENT (3) POPULATION (MILLION) | POLLUTANT PROPERTIES | |
|---|---|---|---|---|---|
| | | | | PHYSICAL(2) | CHEMICAL |
| Stoker Coal Boiler, Industrial | Industrial Fuel | 124,000 | | $P, P_F$ | As, Ba, Be, B, Cr, Cu, Fluorides, Pb, Mn, Hg, Ni, POM, Se, Sn, V, Zn |
| Sintering | Iron & Steel | | | P,Gas | Fluorides, Metal Oxides, Alkalis |
| | Primary Zn | 17 | 0.5 | P,Gas | Zn, Pb, Cd, As, Fluorides |
| | Primary Pb | 10 | 0.3 | P,Gas | As, Cd, Fluorides, Pb, Se |
| Glass Manufacture | Glass Manufacture | 249 | | $P, P_F$<br>No Hazardous Except when Fining, Oxidizing, Color Agents Added | As, Ba, B, Se, Zn, Pb Oxides, Fluorides<br>$Fe_2$, $O_3$ possible, POM |
| Barium Chemicals | Barium Chemicals | 11 | 1.1 | $P, P_F$ | Ba, POM |
| Intermediate Boilers, Oil, Industrial | Industrial Fuel | 152,000 | | $P_F$ | As, Ba, Be, Cr, Cu, Pb, Mn, Hg, Ni, POM, Se, V, Zn |
| Cupola | Grey Iron Foundry | 1,680 | | $P, P_F$,Gas | As, Ba, Be, Pb, Mn, Hg, Ni, V, Zn oxides, POM, Fluorides |

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(2) P - Particulates
$P_F$ - Fine Particulates

(3) Data show total Population of large cities near to known sources

TABLE 3

NUMBER OF SOURCE LOCATIONS AND GENERAL EMISSION CHARACTERISTICS

A. OPERATIONS CONTRIBUTING 90% OF HAZARDOUS POLLUTANTS
(Continued)

| OPERATION | INDUSTRY | NO. OF LOCATIONS | ADJACENT (3) POPULATION (MILLION) | POLLUTANT PROPERTIES PHYSICAL(2) | POLLUTANT PROPERTIES CHEMICAL |
|---|---|---|---|---|---|
| Incinerators | Incinerators | 146 | | $P, P_F$, Gas | As, Cd, Cu, Pb, Hg, POM, Se, Zn |
| Stoker Coal Boiler, Power Plants | Power Plants | 75 | | $P, P_F$ | As, Ba, Be, B, Cr, Cu, Fluorides, Pb, Mn, Hg, Ni, POM, Se, Sn, V, Zn |
| Reverbatory Furnace | Primary Cu | 19 | 0.6 | $P, P_F$, Gas | Cu, Zn, POM, Se, As, Fluorides, Sb |
| | Secondary Pb | 64 | 47.8 | $P, P_F$ | As, Pb, POM |
| | Primary Pb | 10 | 0.3 | $P, P_F$, Gas | As, Cd, Fluorides, Pb, POM, Se |
| | Secondary Cu | 20 | 19.3 | $P, P_F$ | As, Cu, Pb, POM, Se, Sn, Zn |
| Boron Chemicals | Boron Chemicals | 54 | | P | B |
| Barium Milling and Handling | Barium Milling and Handling | 7 | 0.8 | P | Ba |
| Bleaching, All Processes | Bleaching, Pulp Mills | 35 | | Gas | Cl |
| Pulverized Coal Boiler, Industrial | Industrial Fuel | 35,600 | | $P, P_F$, Gas | As, Ba, Be, B, Cr, Cu, Fluorides, Pb, Mn, Hg, Ni, POM, Se, Sn, V, Zn |
| Materials, Handling, MFG | Primary Cu | 19 | 0.6 | P | As, Cd, Cu, Fluorides, Pb, POM, Se |
| | Primary Zn | 17 | 0.5 | P | |
| | Ferro-Alloys | 53 | 3.2 | P | Ni, V, Zn |
| Petroleum Refining | | 263 | | $P_F$, Gas | Pb, POM |

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(2) P - Particulates
$P_F$ - Fine Particulates

(3) Data show total Population of large cities near to known sources

## TABLE 3

## NUMBER OF SOURCE LOCATIONS AND GENERAL EMISSION CHARACTERISTICS (1)

## B. OPERATIONS CONTRIBUTING ASBESTOS, BERYLLIUM OR MERCURY

| OPERATION | INDUSTRY | NO. OF LOCATIONS | ADJACENT POPULATION (MILLION) | POLLUTANT CHARACTERISTICS | |
|---|---|---|---|---|---|
| | | | | PHYSICAL | CHEMICAL |
| Organic Chemicals | Chlorine MFG | 39 | | $P_F$, Gas | Cl, Hg, POM |
| Cyclone Coal Burners, PP | Power Plants | 8 | | $P, P_F$ | As, Ba, Be, B, Cr, Cu, Fl, Pb, Mn, Hg, Ni, POM, Se, Sn, V, Zn |
| Basic Oxygen Furnace | Iron & Steel | 54 | | $P, P_F$ | Ba, Fluorides, Mn, Hg, POM, V. Zn |
| Cyclone Coal Burners, IC | Industrial Fuel | 17,800 | | $P, P_F$ | As, Ba, Be, B, Cr, Cu, Fluoride, Pb, Mn, Hg, Ni, POM, Se, Sn, V, Zn |
| Paint Consumption | Paint Consumption | | | Gas | Hg, POM |
| Residential/ Commercial Coal | Residential Fuel | 92,000 | | $P, P_F$, Gas | As, Ba, Be, B, Cr, Cu, Fluoride, Pb, Mn, Hg, Ni, POM, Se, Sn, V, Zn |
| Brake Lining Production | Asbestos Products | 30 | 20.1 | P | Asbestos, Cr |
| Beryllium Alloys and Chemicals | Be Alloys & Chemicals | 2 | .031 | $P, P_F$ | Be, POM |
| Shingles, Sidings, Manufacture | Asbestos Products | | | P | Asbestos, Cr |
| Primary Mercury | Primary Hg | 24 | | Gas | Hg |
| Lab Use, Mercury | Lab Use, Hg | | | Gas | Hg |
| Asbestos Mat, Installation | Asbestos Mat, Installation | | | P | Asbestos, Cr |
| Secondary Mercury | Secondary Mercury | | | $P_F$, Gas | Hg, POM |
| Asbestos Textiles | Asbestos Products | | | P | Asbestos, Cr |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

TABLE 3

NUMBER OF SOURCE LOCATIONS AND GENERAL EMISSION CHARACTERISTICS
B. OPERATIONS CONTRIBUTING ASBESTOS, BERYLLIUM OR MERCURY
(Continued)

| OPERATION | INDUSTRY | NO. OF LOCATIONS | ADJACENT POPULATION (MILLION) | POLLUTANT CHARACTERISTICS PHYSICAL | POLLUTANT CHARACTERISTICS CHEMICAL |
|---|---|---|---|---|---|
| Paint, Varnish, etc., MFG | Paint, MFG | | | $P, P_F$, Gas | Ba, Hg, POM, Se, Zn |
| Insulating Cement, Installation | Insulating Cement | | | P | Asbestos, Cr |
| Recovery Furnace | Kraft Pulp Milling | 35 | | $P, P_F$, Gas | Asbestos, Cr, Hg, POM |
| Fire Proofing Installation | Fire Proofing | | | P | Asbestos, Cr |
| Beryllium Fabrication | Be Fabrication | | | P | Be |
| Instrument Manufacture | Instrument MFG | | | Gas | Hg |
| Electrical Apparatus | Electrical AP | | | Gas | Hg |
| Dental Preparations, Cons | Dental Prep | | | Gas | Hg |
| Pharmaceuticals Use | Pharmaceuticals | | | Gas | Hg |

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESSES (1)
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | REFERENCES |
|---|---|---|---|---|
| Open Hearth Furnace No Oxygen Lance (composite run) | Iron and Steel | Uncontrolled | 64.7% <5μ<br>6.79% 5-10μ<br>11.9% 10-20μ<br>8.96% 20-44μ<br>7.65% >44μ | 999-AP-40 A.P. Engineering Manual Table 67 (Electron Microscope)<br>Allen et al, 1952: BuMines Inf. Circular 7627 |
|  |  | Typical Electrostatic Precipitator | 58% <5μ<br>34% 5-10μ<br>2% 10-20μ<br>1% 20-44μ<br>5% >44μ | MRI Volume II Figure 8<br>also<br>Englebrecht: Proceedings 28th American Power Conference, April 1966 |
| Open Hearth Furnace Oxygen Lance (Lime Boil) | Iron and Steel | Uncontrolled | 45% <2μ<br>30% 2-5μ<br>17% 5-10μ<br>8% >10μ | MRI Handbook - Table 9-3 (Electron Microscope)<br>Lownie, H. W. and J. Varga, "A System Analysis Study of the Integrated Iron and Steel Industry," Battelle, Contract No. PM-22-68-65, May 1969<br>McCrone, W. C. et al: "The Particle Atlas" Ann Arbor Science Publishers, 1967 |
|  |  | Typical Electrostatic Precipitator | 72% <2μ<br>18% 2-5μ<br>6% 5-10μ<br>4% >10μ | MRI Volume II Figure 8<br>also<br>Englebrecht: op. cit. |
| Open Hearth Furnace Oxygen Lance (composite run) | Iron and Steel | Uncontrolled | 20% <2μ<br>25% 2-5μ<br>24% 5-10μ<br>31% >10μ | MRI Handbook - Table 9-3 (Electron Microscope)<br>Lownie, H. W.: op. cit.<br>McCrone, W.C.: op. cit. |
|  |  | Typical Electrostatic Precipitator | 55% <2μ<br>26% 2-5μ<br>16% 5-10μ<br>3% >10μ | MRI Volume II Figure 8<br>also<br>Englebrecht: op. cit. |

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESSES
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued)

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | | REFERENCES |
|---|---|---|---|---|---|
| Pulverized Coal Boiler | Power Plant | Uncontrolled | 15%<br>10%<br>17%<br>23%<br>16%<br>19% | <3μ<br>3-5μ<br>5-10μ<br>10-20μ<br>20-40μ<br>>40μ | MRI Handbook: BAHCO Analysis |
| | | Electrostatic Precipitator | 38%<br>14%<br>15%<br>7%<br>2%<br>24% | <3μ<br>3-5μ<br>5-10μ<br>10-20μ<br>20-40μ<br>>40μ | MRI Volume II<br>Figure 8<br>also<br>Engelbrecht, Heinz L.: Proceedings 28th American Power Conference, April 1966 |
| | | Cyclone - 6 in. dia. High Efficiency | 61%<br>20%<br>13%<br>5%<br>1%<br>Neg | <3μ<br>3-5μ<br>5-10μ<br>10-20μ<br>20-40μ<br>>40μ | MRI Volume II<br>Figure 13<br>also<br>Burdock: Proceedings 62nd APCA Meeting, June 1969 |
| | | Cyclone - 6 in. dia. High Efficiency Followed By Electrostatic Precipitator | 83%<br>11%<br>5%<br>1%<br>Neg<br>Neg | <3μ<br>3-5μ<br>5-10μ<br>10-20μ<br>20-40μ<br>>40μ | Same as above for cyclone and ESP |
| Oil Burners | Residential/Commercial | Uncontrolled | Est 90% | <1μ | Reference: MITRE Estimate Based On Industrial and Power Plant Oil Burners |
| Metallurgical Coke | Iron and Steel | Uncontrolled | 4%<br>96% | <47μ<br>>47μ | Reference: MRI Handbook: Private Communications with Several Steel Companies |

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESSES
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued)

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | REFERENCES |
|---|---|---|---|---|
| Incineration (continued) | Municipal (continued) | Spray Chamber | 62% <2μ<br>22% 2-10μ<br>3% 10-20μ<br>2% 20-30μ<br>11% >30μ | Stairmand: op. cit. |
| | | Wetted Wall Chamber | Unknown | A.P. Engineering Manual: op. cit. |
| | | Wetted Wall Close Spaced Baffles | Unknown | A.P. Engineering Manual: op. cit. |
| | | Dry Cyclone | 52% <2μ<br>29% 2-10μ<br>8% 10-20μ<br>2% 20-30μ<br>9% >30μ | A.P. Engineering Manual: op. cit. |
| | Domestic | Uncontrolled | Unknown | MRI: op. cit. |
| | | Peabody Scrubber | Unknown | A.P. Engineering Manual: op. cit. |
| Sintering | Iron and Steel | Uncontrolled | 1% <2μ<br>4% 2-10μ<br>15% 10-30μ<br>5% 30-50μ<br>75% >50μ | Southern Research Institute: The Application of Electrostatic Precipitators in the Iron and Steel Industry. Final Report NAPCA Contract CPA-22-69-73, June 1970. (Size Analysis: BAHCO Plus Seive) |
| | | Fabric Filter | 43% <2μ<br>57% 2-10μ<br>0% 10μ | Sommerlad, R. S.: Fabric Filtration State of the Art. Foster Wheeler Corp. March 1967. |
| | | Dry Cyclone | 9% <2μ<br>28% 2-10μ<br>46% 10-30μ<br>3% 30-50μ<br>14% >50μ | A.P. Engineering Manual: op. cit. |

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESSES
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued)

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | REFERENCE |
|---|---|---|---|---|
| Sintering (continued) | Iron and Steel (continued) | Dry Cyclone Plus ESP | 13% <2μ<br>17% 2-10μ<br>27% 10-30μ<br>3% 30-50μ<br>40% >50μ | A. P. Engineering Manual: op. cit.<br>Watkins and Darby: op. cit. |
| | Primary Zinc | Uncontrolled | 100% <10μ | Verein Deutscher Ingenieure, VD1, p.2285 Sept. 1961 (Size Analysis: Unspecified) |
| | | Fabric Filter Plus Wet ESP | 100% <10μ | Sommerlad, R. S.: op. cit.<br>Watkins and Darby: op. cit. |
| | | ESP Plus Wet ESP | 100% <10μ | Watkins and Darby: op. cit. |
| | | Scrubber Plus Wet Wet ESP | 100% <10μ | Kalika, P. W.: op. cit.<br>Watkins and Darby: op. cit. |
| | Primary Lead | Uncontrolled | 15% <10μ<br>85% >10μ | MRI Handbook says similar to copper roasting |
| | | Cyclone Plus Fabric Filter | 100% <10μ<br>0% >10μ | Air Engineering: 28-38, Sept. 1964<br>Sommerlad, R. S.: op. cit. |
| | | Cyclone Plus ESP | 81% <10μ<br>19% >10μ | Air Engineering: op. cit.<br>Watkins and Darby: op. cit. |
| Ore Mining and Handling | Asbestos | Uncontrolled | 100% <40μ | Davis, W. E. & Associates: National Inventory of Sources and Emissions Cadmium, Nickel, and Asbestos |
| | | Cyclone Plus Baghouse | Est. 100% <10μ | |

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESS
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued)

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | | REFERENCES |
|---|---|---|---|---|---|
| Asphalt Blowing | Roofing Material | Uncontrolled | 18%<br>22%<br>28%<br>17%<br>15% | <5μ<br>5-10μ<br>10-20μ<br>20-50μ<br>>50μ | A. P. Engineering Manual<br>(Size Analysis: Unspecified) |
| | | Wet Scrubber and Afterburner | 92%<br>5%<br>3%<br>Neg<br>Neg | <5μ<br>5-10μ<br>10-20μ<br>20-50μ<br>>50μ | Schell, T. W.: Cyclone/Scrubber System Quickly Eliminates Dust Problem. Rock Products 66-68, July 1968 |
| Natural Gas Combustion | Industrial | Uncontrolled | 100% | <5μ | MRI Handbook (Size Analysis: MRI Estimate) |
| Pellet Plants | Iron Ore | Uncontrolled | 1%<br>4%<br>15%<br>5%<br>75% | <2μ<br>2-10μ<br>10-30μ<br>30-50μ<br>>50μ | TRW: Engineering and Cost Effectiveness Study of Fluoride Emissions Control. Jan. 1972<br>Southern Research Institute: op. cit.<br>(Size Analysis: BAHCO plus SEIVE) |
| | | Fabric Filter | 43%<br>57%<br>0% | <2μ<br>2-10μ<br>>10μ | Sommerlad, R. S.: op. cit. |
| | | Dry Cyclone | 9%<br>28%<br>46%<br>3%<br>14% | <2μ<br>2-10μ<br>10-30μ<br>30-50μ<br>>50μ | A.P. Engineering Manual: op. cit. |
| | | Dry Cyclone Plus ESP | 13%<br>17%<br>27%<br>3%<br>40% | <2μ<br>2-10μ<br>10-30μ<br>30-50μ<br>>50μ | A. P. Engineering Manual: op. cit.<br>Watkins and Darby: op. cit. |

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESSES
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued)

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | REFERENCE |
|---|---|---|---|---|
| Bleaching | Pulp and Paper | Uncontrolled | All Gas | E.P.A.: Draft, Control Techniques for Chlorine and Hydrogen Chloride Emissions. March 1971 |
| | | Alkali Scrubber | All Gas | |
| Oil Burners | Power Plants | Uncontrolled | 90% <1μ<br>10% >1μ | MRI Handbook: (Size Analysis: Unknown) |
| | Industrial | Uncontrolled | 90% <1μ<br>10% >1μ | MRI Handbook: (Size Analysis: Unknown) |
| Blast Furnace | Primary Iron and Steel | Uncontrolled | 50%* <74μ<br>50%* >74μ | MRI Handbook: (Size Technique: Unknown) |
| | | * MRI reports particle size highly variable | | |
| | | Settling Chamber | Efficiencies are highly variable depending on chamber parameters. Limit on collection size is usually 40μ or greater. | A.P. Engineering Manual: op. cit. |
| | | High Efficiency Cyclone | 80% <74μ<br>20% >74μ | Turner, B.: Grit Emissions Bay Area APCD Library Accession 9775 |
| | | ESP | 9% <74μ<br>20% >74μ | Watkins and Darby: op. cit. |
| | | Cyclone Plus ESP | 29% <74μ<br>71% >74μ | Turner, B.: op. cit.<br>Watkins and Darby: op. cit. |

BLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESS
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued)

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | REFERENCES |
|---|---|---|---|---|
| Blast Furnace (continued) | Primary Lead | Uncontrolled | 100% <.3μ | MRI Handbook (Size Analysis: Not Specified) |
| | | High Efficiency Cyclone | 96% Penetration at <.3μ | MRI Volume II - Figure 17 |
| | | High Efficiency ESP | 7% " " | MRI Volume II - Figure 17 |
| | | Fabric Filter | 5% " " | MRI Volume II - Figure 17 |
| | Secondary Lead | Uncontrolled | 100% <.4μ | MRI Handbook (Size Analysis: Not Specified) |
| | | High Efficiency ESP | 5% Penetration at <.4μ | MRI Volume II - Figure 17 |
| | | Fabric Filter | 5% " " | " " " |
| | | High Efficiency ESP Plus Fabric Filter | .25% " " | " " " |
| | Secondary Copper | Uncontrolled | 100% <.5μ | MRI Handbook (Size Analysis: Not Specified) |
| | | Fabric Filter | 5% Penetration at <.5μ | MRI Volume II - Figure 17 |
| | Ferroalloys | Uncontrolled | 80% <1μ<br>20% 1-20μ | MRI Handbook (Size Analysis: Not Specified) |
| | | Medium Energy Wet Scrubber | 99% <1μ<br>1% 1-20μ | MRI Volume II<br>Kalika, P. W. op. cit. |
| | | Typical Electrostatic Precifitator | 71% <1μ<br>29% 1-20μ | MRI Volume II<br>Englebrecht, H. L.: op. cit. |
| | | High Efficiency Cyclone | 97% <1μ<br>3% 1-20μ | MRI Volume II<br>Turner, B.: op. cit. |

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESSES
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued)

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | REFERENCES |
|---|---|---|---|---|
| Blast Furnace (continued) | Ferroalloys (continued) | Fabric Filter | 99% <1μ<br>1% 1-20μ | MRI Volume II |
| | Non-Ferrous Alloys | Uncontrolled | 100% <.3μ | A. P. Engineering Manual: op. cit.<br>Allen, G. L., et al.: op. cit. (Size Analysis: Electron Microscope) |
| | | High Efficiency ESP | 7% Penetration at <.3μ | MRI Volume II - Figure 17 |
| | | Fabric Filter | 5% " " | " " " " " |
| | | High Efficiency Cyclone | 96% " " | " " " " " |
| Stoker Coal Boiler | Industrial or Power Plant | Uncontrolled | 9% < 10μ<br>10% 10-20μ<br>17% 20-44μ<br>64% > 44μ | MRI Handbook: op. cit. (average of spreader stoker & underfed stoker) |
| | | Cyclone - 6 in. High Efficiency | 68% < 10μ<br>.6% 10-20μ<br>19% 20-44μ<br>7% >44μ | Burdock: op. cit. |
| | | Typical Electrostatic Precipitator | 2% < 10μ<br>neg. 10-20μ<br>3% 20-44μ<br>95% > 44μ | Englebrecht: op. cit. |
| Gas Burners | Residential, Commercial or Industrial | Uncontrolled | 100% < 5μ | MRI Handbook: op. cit. |
| | | High Efficiency ESP | Avg. 5% Penetration in 0-5μ Range | MRI Volume II - Figure 17 |
| Pulverized Coal Boiler | Industrial | Same as Power Plant Data | | MRI Handbook: op. cit. |

TABLE 4

PARTICLE SIZE DISTRIBUTION FOR EMISSIONS FROM SELECTED PROCESSES
WITHOUT CONTROL DEVICES AND WITH TYPICAL CONTROL DEVICES
(Continued

| PROCESS DESCRIPTION | INDUSTRY | CONTROL DEVICE | PARTICLE SIZE DISTRIBUTION % WEIGHT | REFERENCES |
|---|---|---|---|---|
| Cyclone Coal Boiler | Industrial or Power Plant | Uncontrolled | 40% < 5 μ<br>25% 5-10 μ<br>16% 10-20 μ<br>11% 20-40 μ<br>8% >40 μ | MRI Handbook: op. cit. (BAMCO Analysis) |
| | | Cyclone 6 in.dia. High Efficiency | 83% < 5 μ<br>14% 5-10 μ<br>2% 10-20 μ<br>1% 20-40 μ<br>neg. > 40 μ | Burdock op. cit. |
| | | Typical Electro-static Precipitator | 67% < 5 μ<br>19% 5-10 μ<br>5% 10-20 μ<br>1% 20-40 μ<br>8% > 40 μ | Englebrecht, op. cit. |

## TABLE 5

### EMISSIONS OF PARTICULATES AND FINE PARTICULATES AFTER 100% APPLICATION OF BEST CONTROL DEVICE (1)

| PROCESS | INDUSTRY | BEST DEVICE IN USE | % BY WEIGHT FINE PARTICULATE FOR BEST DEVICE | % APPLICATION OF CONTROL | PRESENT EMISSIONS TONS | EMISSIONS WITH 100% USE OF BEST CONTROL AVAILABLE TONS | FINE PARTICULATE EMISSIONS WITH 100% BEST CONTROL - TONS |
|---|---|---|---|---|---|---|---|
| Open Burning | Agricultural | None | Unknown | 0 | 2,161,142 | No controls Available | Unknown |
| | Forest Fires | None | Unknown | 0 | 1,433,712 | " | Unknown |
| | Refuse Open Burning | None | Unknown | 0 | 526,843 | " | Unknown |
| | Conical Burners | None | Unknown | 0 | 212,211 | " | Unknown |
| | Coal Refuse | None | Unknown | 0 | 193,500 | " | Unknown |
| Open Hearth Furnace No Oxygen Lance (composite run) | Iron & Steel | Electrostatic Precipitator | 58% <5μ | 41% | 68,227 | 3,445 | 1,895 <2μ |
| Oxygen Lance (composite run) | Iron & Steel | Electrostatic Precipitator | 55% <2μ | 41% | | | |
| Pulverized Coal Boiler | Power Plant | Cyclone plus ESP | 83% <3μ | 97%* | 51,471 | 20,164 | 16,736 <3μ |
| Oil Burners | Residential/ Commercial | None | Unknown | 0 | 44,063 | No controls Available | Unknown |
| Metallurgical Coke | Iron & Steel | None | 4% <47μ | 0 | 43,380 | 43,380 | Unknown |
| Chlorine Liquefaction | Chlorine & Alkalis | Return Vents & Alkali Scrubber | 0% All gas | 100% | 43,000 | 43,000 | None |
| Roasting | Primary Copper | Settling, Water Spray plus ESP | 54% <10μ | 100% | 4,373 | 4,373 | 2,361 <10μ |
| | Primary Zinc | Waste Heat Boiler plus Cyclone plus ESP | 37% <5μ | 100% | 34,187 | 34,187 | 12,649 <5μ |
| Incineration | Municipal | Medium Energy Wet Scrubber | 72% <2μ | 100%* | 29,393 | 4,741 | 3,414 <2μ |
| | Domestic | Peabody Scrubber | Unknown | Neg. | 730 | 730 | Unknown |

*Best Control Device Not Universally Used.

** Applying High Efficiency ESP as Best Device.

(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

TABLE 5

EMISSIONS OF PARTICULATES AND FINE PARTICULATES AFTER 100% APPLICATION OF BEST CONTROL DEVICE
(Continued)

| PROCESS | INDUSTRY | BEST DEVICE IN USE | % BY WEIGHT FINE PARTICULATE FOR BEST DEVICE | % APPLICATION OF CONTROL | PRESENT EMISSIONS TONS | EMISSIONS WITH 100% USE OF BEST CONTROL AVAILABLE TONS | FINE PARTICULATE EMISSIONS WITH 100% BEST CONTROL - TONS |
|---|---|---|---|---|---|---|---|
| Sintering | Iron & Steel | Baghouse | 43% <2μ | 100%* | 18,200 | 2,984 | 1,2[illegible] <2μ |
| | Primary Zinc | Baghouse Plus Wet ESP | 100% <10μ | 100%* | 14,400 | 2,880 | 2,880 <10μ |
| | Primary Lead | Cyclone Plus Baghouse | 100% <10μ | 90%* | 1,016 | 230 | 230 <10μ |
| Ore Mining & Handling | Asbestos | Cyclone Plus Baghouse | 100% <40μ | EST 100% | 5,618 | 5,618 | Unknown |
| | Mica (Beryllium) | Cyclone Plus Baghouse | Unknown | EST 100% | 1.4 Lbs. | 1.4 Lbs. | Unknown |
| | Borax | Baghouse | Unknown | 100% | 100 | 100 | Unknown |
| | Manganese | Baghouse | Unknown | 100% | 5 | 5 | Unknown |
| | Copper, Zinc, Lead Barium, Nickel, Mercury, Vanadium | Baghouse | Unknown | EST 35% | 20,605 | 3,008 | Unknown |
| Asphalt Blowing | Roofing Material | Scrubber & Afterburner | 92% <5μ | EST 99% | 23,230 | 23,218 | 21,360 <5μ |
| Natural Gas Combustion | Industrial | None | 100% <5μ | 0 | 20,220 | 20,220 | 20,220 <5μ |
| Pellet Plants | Iron Ore | Baghouse | 43% <2μ | EST 83%* | 18,200 | 719 | 309 <2μ |
| Bleaching | Pulp & Paper | Alkali Scrubber | 0% All gas | 100% | 18,000 | 18,000 | None |
| Oil Burners | Power Plants | None (Except Soot Blow) | 90% <1μ | 0 | 14,273 | 199 ** | 128 ** |
| Oil Burners | Industrial | None (Except Soot Blow) | 90% <1μ | 0 | 14,053 | 196 ** | 126 ** |
| Blast Furnace | Iron & Steel | Cyclone Plus ESP | 50% <74μ | 100% | 7,215 | 7,215 | Unknown |

*Best Control Device Not Universally Used.

**Applying High Efficiency ESP as Best Device.

TABLE 5

EMISSIONS OF PARTICULATES AND FINE PARTICULATES AFTER 100% APPLICATION OF BEST CONTROL DEVICE
(Continued)

| PROCESS | INDUSTRY | BEST DEVICE IN USE | % BY WEIGHT FINE PARTICULATE FOR BEST DEVICE | % APPLICATION OF CONTROL | PRESENT EMISSIONS TONS | EMISSIONS WITH 100% USE OF BEST CONTROL AVAILABLE TONS | FINE PARTICULATE EMISSIONS WITH 100% BEST CONTROL - TONS |
|---|---|---|---|---|---|---|---|
| Blast Furnace (cont'd) | Primary Lead | Cyclone Plus Baghouse | 100% <.3$\mu$ | 98%* | 277 | 198 | 198 |
| | Secondary Lead | High Eff ESP Plus Baghouse | 100% <.4$\mu$ | 100%* | 1,500 | 98 | 98 |
| | Secondary Copper | Baghouse | 100% <.5$\mu$ | 75% | 126 | 22 | 22 |
| | Ferroalloys | High Eff ESP | 80% <1$\mu$ | 100%* | 4,104 | Unknown | Unknown |
| | Non-Ferroalloys | High Eff ESP or Baghouse | 100% <.3$\mu$ | 50% | 130 | 6 | 6 |
| Stoker Coal Boiler | Industrial | High Eff. ESP | 2% 10$\mu$ | 62% * | 13,237 | 1213 | 24 < 10$\mu$ |
| Gas Burners | Residential<br>Commercial | None<br>None | 100% 5$\mu$<br>100% 5 | 0%<br>0% | 10,065 | 503 ** | 503 < 5$\mu$ |
| Gas Burners | Power Plant | None | 100% 5$\mu$ | 0% | 6,151 | 308 ** | 308 < 5$\mu$ |
| Stoker Coal Boiler | Power Plant | High Eff. ESP | 2% 10$\mu$ | 87% * | 5,994 | 1119 | 22 < 10$\mu$ |
| Pulverized Coal Burner | Industrial | High Eff. ESP | 83% 3$\mu$ | 95% * | 3,783 | 1282 | 1064 < 3$\mu$ |
| Cyclone Coal Boiler | Industrial | High Eff. ESP | 83% 5$\mu$ | 91% * | 1,891 | 501 | 416 < 5$\mu$ |
| Cyclone Coal Boiler | Power Plant | High Eff. ESP | 83% 5$\mu$ | 71% * | 1,776 | 218 | 181 < 5$\mu$ |
| Coal Boilers | Residential<br>Commercial | None<br>None | Unknown<br>Unknown | 0%<br>0% | 657 | Unknown<br>Unknown | Unknown<br>Unknown |

* Best Control Device Not Universally Used.

** Applying High Efficiency ESP as Best Device.

## TABLE 6

## CHARACTERIZATION OF GASEOUS AND PARTICULATE EMISSIONS FOR SPECIFICATION OF CONTROL TECHNOLOGY REQUIREMENTS

A. Physical-chemical properties of effluent.

### Bulk Gas

- Flow quantity and rate
- Temperature
- Pressure
- Chemical composition and concentrations
- Humidity
- Variability in flows or system properties

### Particulates

- Total mass loading
- Chemical composition
- Mass loading
- Size profile (specify measuring technique)
- Triboelectric and electrostatic properties
- Wettability
- Abrasiveness
- Density
- Stickiness - caking or agglomerative tendencies
- Corrosiveness
- Hygroscopicity
- Reactivity (wet or dry)
- Toxicity
- Optical properties

B. Properties of the Process Source.

### Configuration

- Effluent flow design characteristics
- Variations in process capacity (frequency & rate of change)
- Space available in vicinity of source
- Special operating or safety considerations
- Reliability & maintainability (MTBF, MTBM)
- Source location - geography, topography, demography

## TABLE 6

## CHARACTERIZATION OF GASEOUS AND PARTICULATE EMISSIONS FOR SPECIFICATION OF CONTROL TECHNOLOGY REQUIREMENTS

(Continued)

### Economics

- Product cost
- Costs of existing control technology
- Contribution of source to be controlled to final product cost
- Impact of source on local economy
- Waste disposal problems

TABLE 7

USUAL AIR CLEANER SELECTIONS FOR INDUSTRIAL PROCESSES

| Operation | Cyclones | High-Efficiency Cyclones | Wet Collectors | Fabric Filter | High-Voltage Electrostatic Precipitators |
|---|---|---|---|---|---|
| | Collector Types Used in Industry | | | | |
| Ceramics | | | | | |
| Raw product handling | Rare | Seldom | Frequent | Frequent | No |
| Fettling | Rare | Occasional | Frequent | Frequent | No |
| Refractory sizing | Seldom | Occasional | Frequent | Frequent | No |
| Glaze and vitreous enamel spray | No | No | Usual | Occasional | No |
| Chemicals | | | | | |
| Material handling | Occasional | Frequent | Frequent | Frequent | Rare |
| Crushing, grinding | Often | Frequent | Frequent | Frequent | No |
| Pneumatic conveying | Usual | Occasional | Rare | Usual | No |
| Roasters, kilns, coolers | Occasional | Usual | Usual | Rare | Often |
| Coal Mining and Power Plant | | | | | |
| Material handling | Rare | Occasional | Frequent | Frequent | No |
| Bunker ventilation | Occasional | Frequent | Occasional | Frequent | No |
| Dedusting, air cleaning | Frequent | Frequent | Occasional | Often | No |
| Drying | Rare | Occasional | Frequent | No | No |
| Fly Ash | | | | | |
| Coal-burning: | | | | | |
| Chain grate | No | Rare | No | No | No |
| Stoker fired | Rare | Usual | No | No | Rare |
| Pulverized fuel | Rare | Frequent | No | No | Frequent |
| Wood-burning | Occasional | Occasional | No | No | No |
| Foundry | | | | | |
| Shake out | Rare | Rare | Usual | Rare | No |
| Sand handling | Rare | Rare | Usual | Rare | No |
| Tumbling mills | No | No | Frequent | Frequent | No |
| Abrasive cleaning | No | Occasional | Frequent | Frequent | No |

## TABLE 7

## USUAL AIR CLEANER SELECTIONS FOR INDUSTRIAL PROCESSES
(Continued)

| | Collector Types Used in Industry | | | | |
|---|---|---|---|---|---|
| Operation | Cyclones | High Efficiency Cyclones | Wet Collectors | Fabric Filter | High Voltage Electrostatic Precipitators |
| Grain Elevator, Flour and Feed Mills | | | | | |
| Grain handling | Usual | Occasional | Rare | Frequent | No |
| Grain dryers | No | No | No | No | No |
| Flour dust | Usual | Often | Occasional | Frequent | No |
| Feed mill | Usual | Often | Occasional | Frequent | No |
| Metal Melting | | | | | |
| Steel blast furnace | Frequent | Rare | Frequent | No | Frequent |
| Steel open hearth | No | No | Doubtful | Possible | Probable |
| Steel electric furnace | No | No | Considerable | Frequent | Rare |
| Ferrous cupola | Rare | Rare | Frequent | Occasional | Occasional |
| Nonferrous reverberatory | No | No | Rare | - | - |
| Nonferrous crucible | No | No | Rare | Occasional | - |
| Metal Mining and Rock Products | | | | | |
| Material handling | Rare | Occasional | Usual | Considerable | - |
| Dryers, kilns | Frequent | Frequent | Frequent | Rare | Occasional |
| Cement rock dryer | Rare | Frequent | Occasional | Frequent | Occasional |
| Cement kiln | Rare | Frequent | Rare | Considerable | Considerable |
| Cement grinding | Rare | Rare | No | Frequent | Rare |
| Cement clinker cooler | Occasional | Occasional | - | - | - |
| Metal Working | | | | | |
| Production grinding, scratch brushing, abrasive cutoff | Frequent | Frequent | Considerable | Considerable | No |
| Portable and swing frame | Frequent | Rare | Frequent | Rare | No |
| Buffing | Frequent | Rare | Frequent | Rare | No |
| Toolroom | Frequent | Frequent | Frequent | Frequent | No |
| Cast iron machining | Rare | Frequent | Considerable | Considerable | No |

TABLE 7

USUAL AIR CLEANER SELECTIONS FOR INDUSTRIAL PROCESSES
(Continued)

| | Collector Types Used in Industry | | | | |
|---|---|---|---|---|---|
| Operation | Cyclones | High Efficiency Cyclones | Wet Collectors | Fabric Filter | High Voltage Electrostatic Precipitators |
| Pharmaceutical and Food Products | | | | | |
| Mixers, grinders, weighing, blending, bagging, packaging | Rare | Frequent | Frequent | Frequent | – |
| Coating pans | Rare | Rare | Frequent | Frequent | No |
| Plastics | | | | | |
| Raw material processing | | | (See comments under chemicals) | | |
| Plastic finishing | Frequent | Frequent | Frequent | Frequent | No |
| Rubber Products | | | | | |
| Mixers | No | No | Frequent | Usual | No |
| Batchout rolls | No | No | Usual | Frequent | No |
| Talc dusting and dedusting | No | No | Frequent | Usual | No |
| Grinding | Often | Often | Frequent | Often | No |

TABLE 8-A

TYPICAL INDUSTRIAL APPLICATION OF WET SCRUBBERS

| Scrubber Type | Typical Application | Usual Range of Particle Sizes, µ | Normal Draft Loss Inc. Water | Maximum Efficiency % |
|---|---|---|---|---|
| Spray Chambers | Dust Cleaning, Electroplating, Phosphate Fertilizer, Kraft Paper, Smoke Abatement | | | |
| Spray Tower | Precooler, Blast Furnace Gas | > 10.0 | 3/4-2 | 85 |
| Centrifugal | Spray Driers, Calciners, Crushers, Classifiers, Fluid Bed Processes, Kraft Paper, Fly Ash | > 2.5 | 2-6 | 95 |
| Impingement Plate | Cupolas, Driers, Kilns, Fertilizer, Flue Gas | | | |
| Venturi | | | | |
| Venturi Throat | Pulverized Coal, Abrasives, Rotary Kilns, Foundries, Flue Gas, Fertilizers, Lime Kilns, Roasting, Titanium Dioxide Processing, Odor Control, Oxygen Steel Making, Coke Oven Gas, Fly Ash | > 0.5 | 6-80 | 99+ |
| Flooded Disk | | > 0.5 | 6-70 | 99+ |
| Multiple Jet | | | | |
| Venturi Jet | Fertilizer Manufacture, Odor Control, Smoke Control | | | |
| Vertical Ventury | Pulverized Coal, Abrasive Manufacture | | | |
| Packed Bed | | | | |
| Fixed | Fertilizer Manufacturing, Plating, Acid Pickling | > 10.0 | 1-6 | 85 |
| Flooded | Acid Vapors, Aluminum Inoculation, Foundries, Asphalt Plants, Atomic Wastes, Carbon Black, Ceramic Frit, Chlorine Tail Gas, Pigment Manufacture, Cupola Gas, Driers, Ferrite, Fertilizer | > 2.5 | 2-8 | 95 |
| Fluid (Floating) Ball | Kraft Paper, Basic Oxygen Steel, Fertilizer, Aluminum Ore Reduction, Aluminum Foundries, Fly Ash, Asphalt Manufacturing | | | |

## TABLE 8-A

## TYPICAL INDUSTRIAL APPLICATION OF WET SCRUBBERS
(Continued)

| Scrubber Type | Typical Application | Usual Range of Particle Sizes, µ | Normal Draft Loss Inc. Water | Maximum Efficiency % |
|---|---|---|---|---|
| Self-Induced Spray | Coal Mining, Ore Mining, Explosive Dusts, Air Conditioning, Incinerators | | | |
| Mechanically-Induced Spray | Iron Foundry, Cupolas, Smoke, Chemical Fume Control, Paint Spray | | | |
| Disintegrator | Blast Furnace Gas | | | |
| Centrifugal Inline Fan | Metal Mining, Coal Processing, Foundry, Food, Pharmaceuticals | | | |
| Wetted Filters | Electroplating, Acid Pickling, Air Conditioning, Light Dust | | | |
| Dust, Mist Eliminators, Fiber Filters | Sulfuric, Phosphoric, and Nitric Acid Mists; Moisture Separators; Household Ventilation; Radioactive and Toxic Dusts, Oil Mists | | | |
| Wire Mesh | Sulfuric, Phosphoric, and Nitric Acid Mists; Distillation and Absorption | | | |
| Baffles | Coke Quenching, Kraft Paper Manufacture, Plating | | | |
| Packed Beds | Sulfuric and Phosphoric Acid Manufacture, Electroplating Spray Towers | | | |

TABLE 8-B

## APPLICATIONS OF CENTRIFUGAL COLLECTORS

| Operation or Process | Air Contaminant | Type of Air Cleaning Equipment | Collector Efficiency, Wt. % |
|---|---|---|---|
| Crushing, Pulverizing, Mixing, Screening | | | |
| Alfalfa Feed Mill | Alfalfa Dust | Cyclone, Settling Chamber | 85 |
| Barley Feed Mill | Barley Flour Dust | Cyclone | 85 |
| Wheat Air Cleaner | Chaff | Cyclone | 85 |
| Grain Elevators | Grain Dust | Cyclone | 85 |
| Drying, Baking | | | |
| Catalyst Regenerator (Petroleum) | Catalyst Dust | Cyclone, ESP | 95 |
| Detergent Powder Spray Drier | Detergent Powder | Cyclone | 85 |
| Orange Pulp Feed Drier | Pulp Dust | Cyclone | 85 |
| Sand Drying Kiln | Silica Dust | Cyclone | 78 |
| Stone Drying Kiln | Silica Dust | Cyclone | 86 |
| Mixing Fluids | | | |
| Asphalt Mixing | Sand and Gravel Dust | Cyclone | 50-86 |
| Bituminous Concrete Mixing | Sand and Stone Dust | Cyclone, Scrubber | 95 |
| Polishing, Buffing, Grinding, Chipping | | | |
| Grinding (Aluminum) | Aluminum Dust | Cyclone | 89 |
| Grinding (iron | Iron Scale and Sand | Cyclone | 56 |
| Grinding (Machine Shop) | Dust | Impeller Collector | 91 |
| Surface Coating | | | |
| Rubber Dusting | Fluffy Zinc Stearate | Impeller Collector | 78-88 |
| Surface Treatment - Physical | | | |
| Abrasive Cleaning | Talc Dust | Cyclone | 93 |
| Abrasive Stick Trimming and Shaping | Silicon Carbide and Alumina Dust | 2 Parallel Cyclones | 51 |
| Casting Cleaning with Metal Shot, Sandblasting and Tumbling | Metallic and Silica Dust | Impeller Collector | 97-99+ |
| Foundry Tumbling | Dust | Impeller Collector | 99 |
| Truing and Shaping Abrasive Products | Silicon Carbide and Alumina Dust | Cyclone | 58 |

TABLE 8-B

## APPLICATIONS OF CENTRIFUGAL COLLECTORS
(Continued)

| Operation or Process | Air Contaminant | Type of Air Cleaning Equipment | Collector Efficiency, Wt. % |
|---|---|---|---|
| Woodworking, Including Plastics<br>Rubber, Paperboard | | | |
| Mill Planing | Wood Dust and Chips | Cyclone | 97 |

TABLE 9

USAGE AND EFFICIENCY OF AVAILABLE CONTROL DEVICES

| Control Device | Source | Type of Pollutant | Particle Size Range μ | Dust Loading (grains/ft$^3$) Inlet | Dust Loading (grains/ft$^3$) Outlet | Efficiency % Total Mass |
|---|---|---|---|---|---|---|
| Wet Scrubber | | | | | | |
| a. Cyclonic Spray Scrubber (Pease-Anthony Type) | Boiler flue gas | Fly ash (pulverized coal) | >2.5 | 0.49-2.58 | 0.02-0.046 | 88-98.8 |
| | Blast furnace (iron) | Iron ore coke | 0.5-20 | 3-24 | 0.03-0.08 | 99 |
| | Lime kiln (Kraft mud) | Lime | 1-25 | 7.7 | 0.25 | 97 |
| | Lime kiln (raw stone) | Lime | 2-40 | 9.2 | 0.08 | 99 |
| | Reverbatory lead furnace | Lead compounds | | 0.5-2 | 0.023-0.04 | 95-98 |
| | Rotary dryer | Ammonium nitrate | large, unstable agglomerates | ... | ... | 99+ |
| | Superphosphate den and mixer | Fluorine compounds | Mist | 0.14 | 0.003 | 97.8 |
| b. Venturi Scrubber | Iron and Steel Industry | | | | | |
| | Gray iron cupola | Iron, coke, silica dust | 0.1-10 | 1-2 | 0.05-0.15 | 95 |
| | Oxygen steel converter | Iron oxide | 0.5-2 | 8-10 | 0.05-0.08 | 98.5 |
| | Steel open hearth furnace (scrap) | Iron and zinc oxide | 0.08-1.00 | 0.5-1.5 | 0.03-0.06 | 95 |
| | Steel open hearth furnace (oxygen lanced) | Iron oxide | 0.02-0.50 | 1.0-6.0 | 0.01-0.07 | 99 |
| | Blast furnace (iron | Iron ore and coke dust | 0.5-20 | 3-24 | 0.008-0.05 | 99 |
| | Electric furnace | Ferro-manganese fume | 0.1-1 | 10-12 | 0.04-0.08 | 99 |
| | Electric furnace | Ferro silicon dust | 0.1-1 | 1-5 | 0.1-0.3 | 92 |
| | Rotary kiln-iron reduction | Iron, carbon | 0.5-50 | 3-10 | 0.1-0.3 | 99 |
| | Crushing and Screening | Taconite iron ore dust | 0.5-100 | 5-25 | 0.005-0.01 | 99.9 |
| | Chemical Industry | | | | | |
| | Acid-humidified $SO_3$ | Sulphuric acid mist | | | | |
| | (a) Scrub with water | | - | 0.13 | 0.0007 | 99.4 |
| | (b) Scrub with 40% acid | | - | 0.176 | 0.0012 | 99.3 |
| | Acid concentrator | Sulphuric acid mist | - | 0.058 | 0.0014 | 97.5 |
| | Copperas roasting kiln | Sulphuric acid mist | - | 0.087 | 0.0009 | 99 |
| | Chlorosulfonic acid plant | Sulphuric acid mist | - | 0.325 | 0.0034 | 98.9 |
| | Phosphoric acid plant | Orthophosphoric acid mist | - | 0.084 | 0.0016 | 98 |
| | Titanium chloride plant, titanium dioxide dryer | Titanium dioxide, hydrogen chloride fumes | 0.5-1 | 1-5 | 0.05-0.1 | 95 |

TABLE 9

## USAGE AND EFFICIENCY OF AVAILABLE CONTROL DEVICES
(Continued)

| Control Device | Source | Type of Pollutant | Particle Size Range μ | Dust Loading (grains/ft$^3$) Inlet | Dust Loading (grains/ft$^3$) Outlet | Efficiency Total Mass |
|---|---|---|---|---|---|---|
| (b) Venturi Scrubber (concluded) | Spray dryers | Detergents, fume and odor | - | - | - | 95 |
| | Flash dryer | Furfural dust | 0.1-1 | 1-1.5 | 0.05-0.08 | 95 |
| | Non-Ferrous Metals Industry | | | | | |
| | Blast furnace (sec. lead) | Lead compounds | 0.1-1 | 2-6 | 0.05-0.15 | 99 |
| | Reverberatory lead furnace | Lead and tin compounds | 0.1-0.8 | 1-2 | 0.12 | 91 |
| | Ajax furnace - magnesium alloy | Aluminum chloride | 0.1-0.9 | 3-5 | 0.02-0.05 | 95 |
| | Zinc sintering | Zinc and lead oxide dusts | 0.1-1 | 1-5 | 0.05-0.1 | 98 |
| | Reverberatory brass furnace | Zinc oxide fume | 0.05-0.5 | 1-8 | 0.1-0.5 | 95 |
| | Mineral Products Industry | | | | | |
| | Lime kiln | Lime dust | 1-50 | 5-10 | 0.05-0.15 | 99 |
| | Lime kiln | Soda fume | 0.3-1 | 0.2-5 | 0.01-0.05 | 99 |
| | Asphalt stone dryer | Limestone and rock dust | 1-50 | 5-15 | 0.05-0.15 | 98 |
| | Cement kiln | Cement dust | 0.5-55 | 1-2 | 0.05-0.1 | 97 |
| | Petroleum Industry | | | | | |
| | Catalytic reformer | Catalyst dust | 0.5-50 | 0.09 | 0.005 | 95 |
| | Acid concentrator | Sulphuric acid mist | - | 0.059 | 0.0014 | 97.5 |
| | TCC catalyst regenerator | Oil fumes | - | 0.330 | 0.0035 | 98 |
| | Fertilizer Industry | | | | | |
| | Fertilizer dryer | Ammonium chloride fumes | 0.05-1 | 0.1-0.5 | 0.05 | 85 |
| | Superphosphate den and mixer | Fluorine compounds | - | 0.134 | 0.0024 | 98 |
| | Pulp Mills | | | | | |
| | Lime kiln | Lime dust, soda fume | 0.1-50 | 2-10 | 0.01-0.15 | 99 |
| | Recovery furnace | Salt cake | - | 4-6 | 0.4-0.6 | 90 |

TABLE 9

USAGE AND EFFICIENCY OF AVAILABLE CONTROL DEVICES
(Continued)

| Control Device | Source | Type of Pollutant | Particle Size Range μ | Dust Loading (grains/ft$^3$) | | Efficiency % |
|---|---|---|---|---|---|---|
| | | | | Inlet | Outlet | Total Mass |
| c. Impingement Baffle Scrubber | Rotary lime kiln gas, paper plant | | | 15 | 0.30 | 98 |
| | Gas from Pyrite roaster | | | 30 | 0.03 | 99 |
| | Gas from blast furnace: | | | | | |
| | Basic iron | | | 5 | 0.05 | 99 |
| | Silvery iron | | | 5 | 0.08 | 80 |
| | Tail gas in carbon black plant | | | 1 | 0.05 | 95 |
| | Boiler flue gas | | | 5 | 0.03 | 94 |
| Electrostatic Precipitator | Electric utility power plants | Fly ash | 0.1-40 | 1-6 | 0.02-0.1 | 95-99 |
| | Iron and Steel | | | | | |
| | Sinter Plant | Sinter dust | 10 (mean) | 0.1-3.0 | 0.05-0.01 | 95-98 |
| | Blast Furnace | Iron ore and coke dust | | 0.05-0.7 | 0.005-0.08 | 94-98 |
| | BOF | Metal oxides | 0.1-5.0 | 2-10 | | 99.2-99.7 |
| | Electric Arc | Metal oxides | 90% < 0.5 | 0.1-3 | | 92-97% |
| | Cement | | | | | |
| | Kilns | Ca and Si oxides | 50%< 8 | 1-70 | 0.03-0.73 | 93.0-99.8 |
| | (wet) | Ca and Si oxides | --- | 14 | 0.02 | 99.86 |
| | (dry) | Ca and Si oxides | --- | 17 | 0.05 | 99.6 |
| | Incinerator | Varied | | | | |
| | (German Data | | 17%< 2 | 2-9 | 0.005-0.03 | 98.6-99.9 |
| | Petroleum | | | | | |
| | Catalyst Regen. | Oxides of alumina | < 1-30 | 0.02-1.0 | --- | 97-99% |
| | Forest Products | | | | | |
| | Kraft-Recovery Furnace | Sodium sulfate and carbonate | 50% < 2 | 3-8 | --- | 85-97 |
| | Lime Manufacturing | | | | | |
| | Kiln | $CaCO_3$, CaO | 50%< 20 | 2-23 | --- | 95% |
| | Iron Foundry Cupola | Metal oxides and coke dust | <1 - 100 | 1/2-10 | 0.06-0.09 | 95-99.7% |
| | $H_2SO_4$ Manufacture | | | | | |
| | Contact Process | $H_2SO_4$ mist | 30%< 2 | 0.02-0.8 | --- | 99.9 |
| | $H_3PO_4$ Manufacture | | | | | |
| | Thermal Process | $H_3PO_4$ mist | 50%< 2 | 7-4,000 | 0.08-10 | 96-99.9+ |

TABLE 10

ESTIMATED ANNUAL BENZO(A)PYRENE ( BAP ) EMISSIONS FOR THE UNITED STATES
(Continued)

| Source | Estimated BaP Emission Rate | Estimated Annual Consumption or Production | Estimated Annual BaP Emission (tons) |
|---|---|---|---|
| Industries | (µg/bl) | ($10^6$ bl) | |
| Petroleum catalytic | | | |
| Cracking (catalyst regeneration) | | | |
| FCC[a] | | | |
| (i) no Co boiler[b] | 240 | 790 | 0.21 |
| (ii) with CO boiler | 14 | 790 | 0.012 |
| HCC[c] | | | |
| (i) no CO boiler | 218,000 | 23.3 | 5.6 |
| (ii) with CO boiler | 45 | 43.3 | 0.0024 |
| TCC[d] (air lift) | (µg/bl) | ($10^6$ bl) | |
| (i) no CO boiler | 90,000 | 131 | 13.0 |
| (ii) with CO boiler | < 45 | 59 | < 0.0029 |
| CC (bucket lift) | | | |
| (i) no CO boiler | | | |
| (ii) with CO boiler | < 31 | 119 | 0.0041 |
| Asphalt road mix | | 0 | 0 |
| Asphalt air blowing | 50 µg/ton | 187,000 tons | 0.000010 |
| Carbon-black manufacturing | < 10,000 µg/ton | 4,400 tons | < 0.000048 |
| Steel & Coke manufacturing | Atmospheric samples indicate that BaP Emissions from these processes are not extremely high | | |
| Chemical complex | | | |
| Total | | | 18.8 |

TABLE 10

ESTIMATED ANNUAL BENZO(A)PYRENE ( BAP ) EMISSIONS FOR THE UNITED STATES*

| Source | Estimated BaP Emission Rate | Estimated Annual Consumption or Production | Estimated Annual BaP Emission (tons) |
|---|---|---|---|
| Heat generation | (μg/$10^6$ Btu) | ($10^{15}$ Btu) | |
| Coal | | | |
| Residential | | | |
| (i) hand-stoked | 1,400,000 | 0.26 | 400 |
| (ii) underfeed | 44,000 | 0.20 | 9.7 |
| Commercial | 5,000 | 0.51 | 2.8 |
| Industrial | 2,700 | 1.95 | 5.8 |
| Electric generation | 90 | 6.19 | 0.6 |
| Oil | 200 | 6.79 | 1.5 |
| Gas | 100 | 10.57 | 1.2 |
| Total | | | 421.6 |
| Refuse burning | (μg/ton) | ($10^6$ tons) | |
| Incineration | | | |
| Municipal | 5,300 | 18 | 0.1 |
| Commercial | 310,000 | 14 | 4.8 |
| Open burning | | | |
| Municipal refuse | 310,000 | 14 | 4.8 |
| Grass, leaves | 310,000 | 14 | 4.8 |
| Auto components | 26,000,000 | 0.20 | 5.7 |
| Total | | | 20.2 |

* Reproduced from Litton Report (Ref. 34)

TABLE 10

ESTIMATED ANNUAL BENZO(A)PYRENE ( BAP ) EMISSIONS FOR THE UNITED STATES
(Continued)

| Source | Estimated BaP Emission Rate | Estimated Annual Consumption or Production | Estimated Annual BaP Emission (tons) |
|---|---|---|---|
| Motor vehicles | (µg/gal) | ($10^{10}$ gal) | |
| Gasoline | | | |
| Automobiles | 170 | 4.61 | 8.6 |
| Trucks | >460 | 2.01 | >10 |
| Diesel | 690 | 0.257 | 2.0 |
| Total | | | > 20.6 |
| Total (all sources tested) | | | 481 |

[a] FCC: fluid catalytic cracker.

[b] CO boiler: carbon monoxide waste heat boiler.

[c] HCC: Houdriflow catalytic cracker.

[d] TCC: Thermo for catalytic cracker.

TABLE 11

ODOR EMISSIONS FROM TYPICAL INDUSTRIAL EQUIPMENT AND ODOR CONTROL DEVICES

| Type of Equipment or Operation | Odor Levels and Emission Rates, Uncontrolled | | Odor Levels and Emission Rates, Controlled | | | |
|---|---|---|---|---|---|---|
| | Vent Gas Odor Concentration Range (ou/scf$^a$) | Modal Odor Emission Rate (ou/min$^b$) | Type of Odor Control Equipment | Vent Gas Odor Concentration (ou/scf$^a$) | Odor Emission Rate (ou/min$^b$) | Temperature$^c$ and Efficiency$^d$ |
| Rendering cooker | 5,000 to 500,000$^e$<br>(Mode 50,000) | 25,000,000 | Direct-Fired(DF)* | 100 to 150 (Mode 120) | 90,000 | 1,200°F 99+% |
| | | | Surface condenser** | 100,000 to 10,000,000$^f$ (Mode 500,000) | 12,000,000 | 80°F Negative$^f$ |
| | | | Jet condenser followed by a D-F after-burner* | 20 to 50 (Mode 25) | 2,000 | 1,200°F 99+% |
| | | | Surface condenser followed by a D-F after-burner* | 50 to 100 (Mode 75) | 6,000 | 1,200°F 99+% |
| | | | Jet (or contact condenser)** | 2,000 to 20,000 (Mode 10,000) | 70,000 | 80°F 80% |
| Rendering Cooker (Blood drying) Dry batch type | 10,000 to 1,000,000$^g$ | Not measured | | | | |
| Rendering cooker (Edible charge)<br>Dry batch type<br>Wet Batch type<br>Continuous type | <br>2,500$^h$<br>350$^h$<br>650 to 7,000$^{h,i}$ | <br>70,000$^h$ | | | | |

Reproduced from Litton Report (Ref. 34)

TABLE 11

ODOR EMISSIONS FROM TYPICAL INDUSTRIAL EQUIPMENT AND ODOR CONTROL DEVICES

(Continued)

| Type of Equipment or Operation | Odor Levels and Emission Rates, Uncontrolled | | Odor Levels and Emission Rates, Controlled | | | |
|---|---|---|---|---|---|---|
| | Vent Gas Odor Concentration Range (ou/scf[a]) | Modal Odor Emission Rate (ou/min[b]) | Type of Odor Control Equipment | Vent Gas Odor Concentration (ou/scf[a]) | Odor Emission Rate (ou/min[b]) | Temperature[c] and Efficiency[d] |
| Fish-meal drier | 1,000 to 5,000 (Mode 2,000) | 50,000,000 | Packed column type scrubber** | 200 to 1,000 (Mode 400) | 10,000,000 | 70°F 80% |
| | | | Chlorination[k] plus packed column scrubber** | 30 to 50 (Mode 40) | 1,000,000 | 70°F 98% |
| Air blowing of fish oils | 10,000 to 70,000 (Mode 50,000) Estimated) | 30,000,000 | Direct-fired afterburner* | 25 to 75 (Mode 50) (Estimated) | 50,000[l] | 1,200°F 99+% |
| Air blowing of linseed oil | 120,000[h] | not measured | Direct-fired afterburner* | 2,000 | not measured | 1,200°F 97.5% |
| Varnish cooker batch type | 10,000 to 200,000[e] (Mode 25,000) | 10,000,000 | Recirculating spray contact scrubber followed by a DF afterburner* | 10 to 25 (Mode 20) | 10,000 | 1,200°F 99+% |
| | | | Recirculating spray (contact) scrubber** | 20,000 | not measured | |
| | | | Direct fired afterburner* | 100 to 400 (Mode 250) | 100,000 | 1,200°F 99% |
| | | | Recirculating spray (contact) scrubber** | 100,000[h] | not measured | |

TABLE 11

ODOR EMISSIONS FROM TYPICAL INDUSTRIAL EQUIPMENT AND ODOR CONTROL DEVICES

(Continued)

| Type of Equipment or Operation | Odor Levels and Emission Rates, Uncontrolled | | Odor Levels and Emission Rates, Controlled | | | |
|---|---|---|---|---|---|---|
| | Vent Gas Odor Concentration Range (ou/scf[a]) | Modal Odor Emission Rate (ou/min[b]) | Type of Odor Control Equipment | Vent Gas Odor Concentration (ou/scf[a]) | Odor Emission Rate (ou/min[b]) | Temperature[c] and Efficiency[d] |
| Lithographing oven metal decorating | 700 to 10,000[j] (Mode 3,000) | 15,000,000 | Direct-fired afterburner* | 50 to 500 (Mode 200) | 1,200,000 | 1,200°F<br>95% |
| | | | Catalytic afterburner* | 450[n]<br>3,000[h] | 2,300,000 | 1,000°F[m]<br>800°F |
| Coffee roaster batch type | 300 to 30,000[e] | 3,000,000[h] (Estimated) | Direct-fired afterburner | 150 to 15,000[n] | 1,700,000[h] (Estimated) | 1,100°F<br>50% |
| Coffee roaster continuous type | 500 to 1,000[j] (Mode 1,000) (Estimated) | 3,000,000[l] | Direct-fired afterburner* | 300 to 1,000 (Mode 350) (Estimated) | 1,200,000[l] | 900°F<br>65% |
| Bread baking oven | 1,000[h] | Not measured | | | | |
| Tallow hydrolyzer | Not measured | Not measured | Surface condenser[o] followed by a direct-fired afterburner* | 2,000,000<br>2,000<br>750<br>150<br>70 | Not measured | 940°F<br>1,100°F<br>1,200°F<br>1,300°F<br>1,400°F |
| | | | Surface condenser** | 6,000 | Not measured | |

TABLE 11

ODOR EMISSIONS FROM TYPICAL INDUSTRIAL EQUIPMENT AND ODOR CONTROL DEVICES

(Continued)

| Type of Equipment or Operation | Odor Levels and Emission Rates, Uncontrolled | | Odor Levels and Emission Rates, Controlled | | | |
|---|---|---|---|---|---|---|
| | Vent Gas Odor Concentration Range (ou/scf[a]) | Modal Odor Emission Rate (ou/min[b]) | Type of Odor Control Equipment | Vent Gas Odor Concentration (ou/scf[a]) | Odor Emission Rate (ou/min[b]) | Temperature[c] and Efficiency[d] |
| Phthalic anhydride manufacturing unit | 1,800 to 3,500[j] (Mode 2,500) | 15,000,000 | Direct-fired afterburner* | 45 to 120 (Mode 75) | 500,000 | 1,200°F<br>97% |
| | | | Catalytic afterburner* | 1,800 | 11,000,000 | 745°F<br>27% |
| | | | Catalytic afterburner* | 180 | 1,100,000 | 815°F[m]<br>93% |

*Afterburner odor control devices.

**Nonafterburner odor control devices.

[a] Odor units per standard cubic foot (at 70°F and 14.7 psia).

[b] Odor units discharged per minute, based on average volumetric discharge rate and modal odor concentration.

[c] Temperature of gases after leaving flame-contact zone (afterburners); temperature of vent gases in other gases.

[d] Odor control efficiency, on a modal odor concentration basis.

[e] Odor concentrations in batch processes vary with materials charged and phase of operation.

[f] Surface condensers increase odor concentrations in the vent gases but reduce total odor emission rates.

[g] Hundred-fold increase from beginning to end of cycle.

[h] One test only.

[i] Samples collected from several points of odor emissions.

[j] In continuous processes, odor concentrations vary with temperatures maintained and materials charged.

[k] Chlorine (20 ppm) mixed with drier off-gases, which are then scrubbed. More or less chlorine increases odor concentrations.

[l] Estimated from two tests only.

[m] Maximum temperature at which this catalytic unit can operate.

[n] Outlet odor concentration rises and falls with inlet odor concentration.

[o] The surface condenser is an integral part of the hydrolyzing unit. Note that low temperature incineration increases odor concentration above condenser vent level.

TABLE 12 (143)

ODOR CONTROL METHODS AND THEIR EFFECTIVENESS

| Control Method | Efficiency |
|---|---|
| Adsorption by activated carbon | 80% |
| Filtration (dry scrubbing) | 75% |
| Absorption with water | 71% |
| Absorption w/chlorinated water | 80% |
| Absorption w/hypochlorite | 80% |
| Absorption w/proprietary chemicals in water | 27% |
| Electrostatic precipitation | 86% |
| Direct flame incineration | 78% |
| Catalytic combustion (i.e., 'Decatox') | 100% |
| Masking w/chemicals | 47% |
| Neutralisation or counteraction with chemicals | 57% |

TABLE 13**

## ODOR REMOVAL EFFICIENCIES OF CONDENSERS OR AFTERBURNERS, OR BOTH, VENTING A TYPICAL DRY RENDERING COOKER*

| Concentration (odor units/scf) | Emission Rate (odor units/min) | Condenser Type | Condensate Temperature ($^{o}F$) | Afterburner Temperature ($^{o}F$) | Concentration (Odor units/sfc) | Modal Emission Rate (odor units/min) | Odor Removal Efficiency % |
|---|---|---|---|---|---|---|---|
| 50,000 | 25,000,000 | None | | 1,200 | 100 to 150 (Mode 120) | 90,000 | 99.40 |
| | | Surface | 80 | None | 100,000 to 10 million (Mode 500,000) | 12,500,000 | 50 |
| | | Surface | 140 | 1,200 | 50 to 100 (Mode 75) | 6,000 | 99.98 |
| | | Contact | 80 | None | 2,000 to 20,000 (Mode 10,000) | 250,000 | 99 |
| | | Contact | 140 | 1,200 | 20 to 50 (Mode 25) | 2,000 | 99.99 |

*Based on a hypothetical cooker that emits 500 scfm of vapor containing 5 percent noncondensible gases.

**From Reference 33.

## TABLE 14

## AMBIENT AIR QUALITY VALUES FOR POTENTIALLY HAZARDOUS POLLUTANTS

μg/m$^3$ Except As Noted

| ELEMENT | TOXICITY FACTOR (1) | OBSERVED VALUES MAXIMUM (2,3) | MINIMUM (3,4) | ESTIMATED SAFE LEVELS (5) | | | |
|---|---|---|---|---|---|---|---|
| | | | | TLV/100. WORKDAY TIME-WEIGHTED AVG. | SCHROEDER(6) 3 Nov 72 | CHRISTENSEN(6) 9 Nov 72 | ELKINS (6) 22 Nov 72 |
| ARSENIC As | T | | | 5. | .15 | 10. | 10. |
| ASBESTOS | N | | | .05 fiber/ ml | | 1. fiber/ ml | .1 fiber/ ml |
| BARIUM Ba | N | 1.50 /.00 | | 5. | 200. | 10. | 25. |
| BERYLLIUM * Be | T | .002/.00019 | .0002/.00007 | .02 | 0. | .2 | .001 |
| BORON B | N | | | 100. | | | 50. |
| CADMIUM * Cd | T | .37 /.043 | .01 /.0005 | 1. oxide fume CL<br>2. soluble salts & dust | 0. | 1. | 5. |
| CHLORINE Cl | N | | | 30. | | 30. | 30. |
| CHROMIUM Cr | E | .10 /.270 | .006 /.0002 | 5. soluble salts<br>10. metallic & insoluble salts | 1. | 10. | 10. |
| COPPER Cu | E | 1.20 /.25 | .01 /.002 | 1. fume<br>10. dust | | 10. | 10. |
| FLUORIDES F | E | 1.89 /.16 | .05 /.05 | 25. | 10. | 100. | 50. |
| LEAD * Pb | T | 16.00 /.20 | .04 /.006 | 2. | .5 | 10. | 5. |
| MANGANESE * Mn | E | 1.44 /.08 | .01 /.006 | 50. CL | 1. | 20. | 25. |
| MERCURY Hg | T | | | .5 | .1 | .1 | 2. |
| NICKEL * Ni | T | .42 /.76 | .006 /.002 | 10. | .03 | 10. | 10. |
| POM | | | | | | | |
| SELENIUM Se | N | | | 2. | .1 | 10. | 10. |
| TIN * Sn | T | .10 /.01 | | 20. | .03 | 20. | 20. |
| VANADIUM V | E | 1.30 /.024 | .003 /.0005 | 1. organic<br>.5 fume<br>5. dust CL | 10. | 10. | 5. |
| ZINC Zn | E | 2.80 /.77 | .2 /.0003 | 50. | | 10. | 50. |

---

(1) N = Non-toxic
T = Toxic
E = Essential

(2) Schroeder, H., "A Sensible Task of Air Pollution by Metals."

(3) Air Quality Data for 1967 (Rev. '71) EPA, p. 5

(4) By Emission Spectograph Method for Metals Ashed with Low Temperature Oxygen Plasma Asher.

(5) 24 Hr. averages except as noted.

CL=Ceiling limit boundary value.

(6) Henry A. Schroeder, M.D., Professor of Physiology, Emeritus Dartmouth Medical School.
Herbert E. Christensen, D.Sc. Head, Toxicity and Research Analysis Branch, NIOSH.
Harvey B. Elkins, M.D., Division of Occupational Hygiene, Department of Labor and Industries, Commonwealth of Massachusetts.

# APPENDIX A

## HAZARDOUS POLLUTANT SOURCES TABULATED BY POLLUTANT

This appendix contains a series of tables which reproduce the data presented in Table 1 summarizing the total emissions by weight. Here, the information is arranged so that the distribution of emissions for each pollutant is identified and collected separately for quick reference.

## HAZARDOUS POLLUTANT SOURCES (1)

### ARSENIC

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Mining | <1 | NEG |
| Phosphate Rock | NEG | NEG |
| Primary Copper | | |
| Roasting | 900 | 10.07 |
| Reverberatory Furnaces | 400 | 4.48 |
| Converters | 1,150 | 12.87 |
| Material Handling | 250 | 2.80 |
| Primary Zinc | | |
| Roasting | 1,390 | 15.55 |
| Primary Lead | | |
| Sintering | 285 | 3.19 |
| Blast Furnace | 80 | 0.90 |
| Reverberatory Furnace | 11 | 0.12 |
| Gray Iron Foundary | 97 | 1.09 |
| Cotton Ginning | 19 | 0.21 |
| Non-Ferrous Alloys | NEG | NEG |
| Phosphoric Acid | NEG | NEG |
| Glass Manufacture | 638 | 7.14 |
| Wood Preservatives | NEG | NEG |
| Miscellaneous Arsenic Chemicals | 3.3 | 0.04 |
| Arsenic Pesticide Production | 197 | 2.20 |
| Pesticide, Herbicide, Fungicide Use | 2,925 | 32.72 |
| Power Plant Boilers | | |
| Pulverized Coal | 429 | 4.80 |
| Stoker Coal | 49 | 0.55 |
| Cyclone Coal | 15 | 0.17 |
| Industrial Boilers | | |
| Pulverized Coal | 19 | 0.21 |
| Stoker Coal | 67 | 0.75 |
| Cyclone Coal | 9 | 0.10 |
| All Oil | NEG | NEG |
| Residential/Commercial Coal | 6 | 0.07 |
| TOTAL | 8,939 | 100 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### ASBESTOS

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Asbestos Mining | 5,610 | 89.6 |
| Kraft Pulp Mill Recovery Furnace | 15 | 0.24 |
| Sulfite Pulp Mill | NEG | NEG |
| Asbestos Products | | |
| Brake Lining Production | 312 | 4.98 |
| Shingle & Siding Production | 205 | 3.27 |
| Asbestos Textile Production | 18 | 0.29 |
| Installation of Asbestos Construction Material | 61 | 0.97 |
| Spray on Steel Fire Proofing | 15 | 0.24 |
| Insulating Cement Application | 25 | 0.40 |
| TOTAL | 6,261 | 99.99 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES(1)

## BARIUM

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Barium Mining | 30 | 0.28 |
| Blast Furnace | 112 | 1.04 |
| Open Hearth | 38 | 0.35 |
| Basic Oxygen Furnace | 20 | 0.19 |
| Electric Arc Furnace | 36 | 0.33 |
| Gray Iron Foundry Cupola | 50 | 0.46 |
| Glass Manufacture | 40 | 0.37 |
| Barium Milling & Handling | 2,700 | 24.94 |
| Barium Chemicals | 4,400 | 40.64 |
| Paint, Varnish, etc. Manufacture | 30 | 0.28 |
| Well Drilling Mud | 70 | 0.65 |
| Power Plant Boilers | | |
| Pulverized Coal | 2,311 | 21.35 |
| Stoker Coal | 266 | 2.46 |
| Cyclone Coal | 80 | 0.74 |
| All Oil | 29 | 0.27 |
| Industrial Boilers | | |
| Pulverized Coal | 102 | 0.94 |
| Stoken Coal | 358 | 3.31 |
| Cyclone Coal | 51 | 0.47 |
| All Oil | 22 | 0.20 |
| Residential/Commercial Boilers | | |
| Coal | 32 | 0.30 |
| Oil | 49 | 0.45 |
| TOTAL | 10,826 | 100.02 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### BERYLLIUM

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Mica, Feldspar Mining | NEG | NEG |
| Gray Iron Foundry | | |
| Cupola | 4 | 2.77 |
| Ceramic Coatings | NEG | NEG |
| Beryllium Alloys & Compounds | 5 | 3.64 |
| Beryllium Fabrication | NEG | NEG |
| Power Plant Boilers | | |
| Pulverized Coal | 86 | 59.62 |
| Stoker Coal | 10 | 6.93 |
| Cyclone Coal | 3 | 2.08 |
| All Oil | 2 | 1.39 |
| Industrial Boilers | | |
| Pulverized Coal | 8 | 5.55 |
| Stoker Coal | 13 | 9.01 |
| Cyclone Coal | 2 | 1.39 |
| All Oil | 2 | 1.39 |
| Residential/Commercial Boilers | | |
| Coal | 1 | 0.69 |
| Oil | 8 | 5.55 |
| TOTAL | 144 | 100.01 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### BORON

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Borax Mining | 100 | 1.05 |
| Glass Manufacturing | 1,000 | 10.55 |
| Boron Chemicals | 2,400 | 25.32 |
| Ceramic Coatings | 470 | 4.96 |
| Soaps and Detergent Manufacturing | 13 | 0.14 |
| Use of Pesticides, Herbicides, and Fungicides | 1,800 | 18.99 |
| Sewage and Sludge Incineration | 20 | 0.21 |
| Power Plant Boilers | | |
| Pulverized Coal | 2,655 | 28.01 |
| Stoker Coal | 304 | 3.21 |
| Cyclone Coal | 91 | 0.96 |
| Industrial Boilers | | |
| Pulverized Coal | 118 | 1.25 |
| Stoker Coal | 413 | 4.36 |
| Cyclone Coal | 59 | 0.62 |
| Residential/Commercial Boilers | | |
| Coal | 37 | 0.39 |
| TOTAL | 9,480 | 100.02 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

## CADMIUM

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Copper Mining | NEG | NEG |
| Zinc Mining | <1 | 0.01 |
| Lead Mining | NEG | NEG |
| Primary Copper | | |
| Roasting | 229 | 7.59 |
| Reverberatory Furnace | 94 | 3.12 |
| Converters | 270 | 8.95 |
| Material Handling | 59 | 1.96 |
| Primary Zinc | | |
| Roasting | 666 | 22.07 |
| Sintering | 284 | 9.41 |
| Distillation | 90 | 2.98 |
| Material Handling | NEG | NEG |
| Primary Nickel | NEG | NEG |
| Primary Lead | | |
| Sintering | 66 | 2.19 |
| Blast Furnace | 19 | 0.63 |
| Reverberatory | 3 | 0.10 |
| Material Handling | NEG | NEG |
| Secondary Copper | | |
| Sweating Furnace | 70 | 2.32 |
| Blast Furnace | 55 | 1.82 |
| Iron & Steel | | |
| Blast Furnace | 1,000 | 33.14 |
| Non-Ferrous Alloys | | |
| Furnaces | 3 | 0.10 |
| Material Handling | NEG | NEG |
| Cadmium Paint Pigments | 11 | 0.36 |
| Cadmium-Barium Plastic Stabilizers | 3 | 0.10 |
| Cadmium-Nickel Batteries | <1 | 0.01 |
| Miscellaneous Cadmium Products | <1 | 0.02 |
| Use of Pesticides, Herbicides and Fungicides | <1 | 0.01 |
| Fertilizer Application | <1 | 0.02 |
| Incinerators | 95 | 3.15 |
| TOTAL | 3,018 | 100.06 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES(1)

### CHLORINE

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Chlorine Fluxing | | |
| Non-Ferrous Metals | 100 | 0.13 |
| Iron and Steel | 1,900 | 2.43 |
| Bleaching, Pulp and Paper | 18,000 | 23.02 |
| Chlorine Industry | | |
| Manufacture | 4,000 | 5.12 |
| Liquefaction and Handling | 43,000 | 54.99 |
| Organic Chlorine Chemicals | 8,500 | 10.87 |
| Hydrochloric Acid Manufacture | 800 | 1.02 |
| Bleach Manufacture | 900 | 1.15 |
| Miscellaneous Chlorine Products | 1,000 | 1.28 |
| TOTAL | 78,200 | 100.01 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### CHROMIUM

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Asbestos Mining | 8 | 0.07 |
| Kraft Pulp Mill Recovery Furnace | NEG | NEG |
| Sulfite Pulp Mill | NEG | NEG |
| Primary Chromium Production | 4200 | 34.98 |
| Asbestos Products | NEG | NEG |
| Refractory Brick Production | 7 | 0.06 |
| Installation of Asbestos Material | NEG | NEG |
| Spray-on Fire Proofing | NEG | NEG |
| Use of Insulating Cement | NEG | NEG |
| Power Plant Boilers | | |
| Pulverized Coal | 5,571 | 46.40 |
| Stoker Coal | 640 | 5.33 |
| Cyclone Coal | 192 | 1.60 |
| All Oil | 22 | 0.18 |
| Industrial Boilers | | |
| Pulverized Coal | 247 | 2.06 |
| Stoker Coal | 864 | 7.20 |
| Cyclone Coal | 123 | 1.02 |
| All Oil | 17 | 0.14 |
| Residential/Commercial Boilers | | |
| Coal | 77 | 0.64 |
| Oil | 38 | 0.32 |
| TOTAL | 12,006 | |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### COPPER

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Copper Mining | 190 | 1.41 |
| Primary Copper | | |
| Roasting | 2,900 | 21.54 |
| Reverberatory Furnace | 1,243 | 9.23 |
| Converters | 3,729 | 27.70 |
| Material Handling | 828 | 6.15 |
| Secondary Copper | | |
| Scrap Prepatation | 5 | 0.04 |
| Wire Burning | 155 | 1.15 |
| Sweating Furnace | 15 | 0.11 |
| Blast Furnace | 15 | 0.11 |
| Smelting, Reverberatory | 15 | 0.11 |
| Smelting, Rotary | 5 | 0.04 |
| Iron and Steel | | |
| Blast Furnace | 1,070 | 7.95 |
| Open Hearth Furnace | 1,550 | 11.51 |
| Basic Oxygen Furnace | 70 | .52 |
| Electric Arc Furnace | 70 | .52 |
| Gray Iron Foundry | 50 | .37 |
| Miscellaneous Copper Metals and Alloys | 2 | 0.02 |
| Miscellaneous Copper Chemicals and Products | 230 | 1.71 |
| Incinerators | 460 | 3.42 |
| Power Plant Boilers | | |
| Pulverized Coal | 585 | 4.35 |
| Stoker Coal | 67 | 0.50 |
| Cyclone Coal | 20 | 0.15 |
| All Oil | 15 | 0.11 |
| Industrial Boilers | | |
| Pulverized Coal | 26 | 0.19 |
| Stoker Coal | 91 | 0.68 |
| Cyclone Coal | 13 | 0.10 |
| All Oil | 11 | 0.11 |
| Residential/Commercial Boilers | | |
| Coal | 8 | 0.06 |
| Oil | 25 | 0.19 |
| Total | 13,463 | |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### FLUORIDES

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Iron Ore Pellet Plants | 18,200 | 11.36 |
| Defluorination of Phosphate Rock | 1,760 | 1.10 |
| Primary Aluminum | | |
| Reduction, H.S. Soderberg | 5,160 | 3.22 |
| Reduction, V.S. Soderberg | 2,460 | 1.54 |
| Prebake | 8,610 | 5.37 |
| Primary Copper | | |
| Roasting | 200 | 0.13 |
| Reverberatory Furnaces | 86 | 0.05 |
| Converters | 257 | 0.16 |
| Material Handling | 57 | 0.04 |
| Primary Zinc | | |
| Roasting | 127 | 0.08 |
| Sintering | 55 | 0.03 |
| Distillation | 18 | 0.01 |
| Primary Lead | | |
| Sintering | 150 | 0.09 |
| Blast Furnace | 40 | 0.03 |
| Dross Reverberatory Furnace | 10 | 0.01 |
| Iron and Steel | | |
| Sintering | 18,200 | 11.36 |
| Blast Furnace | 2,800 | 1.75 |
| Open Hearth | 25,400 | 15.85 |
| Phosphoric Acid Production | 6,830 | 4.26 |
| Hydrofluoric Acid Production | 700 | 0.44 |
| Hydrofluoric Acid Alkylation | 5,800 | 3.62 |
| Glass Manufacture, Frit Production | 700 | 0.44 |
| Expanded Clay Aggregate Preparation | 5,300 | 3.31 |
| Diammonium Phosphate Preparation | 280 | 0.18 |
| Triple Superphosphate Preparation | 3,780 | 2.36 |
| Normal Superphosphate Preparation | 4,970 | 3.10 |
| Electrothermal Phosphorous Preparation | 4,080 | 2.55 |

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1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES

### FLUORIDES (Continued)

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Cement Kilns | 270 | 0.17 |
| Structural Clay Products | 9,720 | 6.07 |
| Power Plant Boilers | | |
| Pulverized Coal | 24,696 | 15.41 |
| Stoker Coal | 2,839 | 1.77 |
| Cyclone Coal | 852 | 0.53 |
| Industrial Boilers | | |
| Pulverized Coal | 1,092 | 0.68 |
| Stoker Coal | 3,830 | 2.39 |
| Cyclone Coal | 547 | 0.34 |
| Residential/Commercial Boilers | | |
| Coal | 342 | 0.21 |
| TOTAL | 160,218 | 100.01 |

## HAZARDOUS POLLUTANT SOURCES (1)

## LEAD

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Copper, Zinc, Lead Mining | 345 | 3.72 |
| Primary Copper | | |
| Roasting | 127 | 1.37 |
| Reverberatory Furnaces | 54 | 0.58 |
| Converters | 163 | 1.76 |
| Material Handling | 36 | 0.39 |
| Primary Zinc | | |
| Roasting | 159 | 1.71 |
| Sintering | 68 | 0.73 |
| Distillation | 23 | 0.25 |
| Primary Nickel | 246 | 2.65 |
| Primary Lead | | |
| Sintering | 510 | 5.49 |
| Blast Furnace | 136 | 1.47 |
| Dross Reverberatory Furnace | 68 | 0.73 |
| Secondary Copper | | |
| Wire Burning | 390 | 4.20 |
| Sweating Furnace | 42 | 0.45 |
| Blast Furnace | 42 | 0.45 |
| Smelting, Reverberatory | 42 | 0.45 |
| Smelting, Rotary | 4 | 0.04 |
| Secondary Lead | | |
| Scrap Preparation | NEG | NEG |
| Blast Furnace | 1,500 | 16.16 |
| Reverberatory Furnace | 500 | 5.39 |
| Pot Refining | NEG | NEG |
| Barton Process | 20 | 0.22 |
| Iron and Steel | | |
| Open Hearth | 150 | 1.62 |
| Gray Iron Foundry | | |
| Cupola | 1,400 | 15.08 |
| Petroleum Refining | 1,250 | 13.47 |
| Lead Alkyl Chemicals | 810 | 8.73 |
| Cadmium-Nickel Battery Production | 2 | 0.02 |
| Use of Pesticides, Herbicides, Fungicides | NEG | NEG |
| Incinerators | 320 | 3.45 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES

### LEAD (Continued)

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Power Plant Boilers | | |
| Pulverized Coal | 614 | 6.62 |
| Stoker Coal | 71 | 0.77 |
| Cyclone Coal | 21 | 0.23 |
| All Oil | 7 | 0.08 |
| Industrial Boilers | | |
| Pulverized Coal | 27 | 0.29 |
| Stoker Coal | 95 | 1.02 |
| Cyclone Coal | 14 | 0.15 |
| All Oil | 5 | 0.05 |
| Residential/Commercial Boilers | | |
| Coal | 9 | 0.10 |
| Oil | 12 | 0.13 |
| TOTAL | 9,280 | 100.02 |

## HAZARDOUS POLLUTANT SOURCES(1)

### MANGANESE

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Manganese Mining | 5 | 0.03 |
| Primary Manganese Preparation | 325 | 1.71 |
| Iron and Steel | | |
| Blast Furnace | 1,000 | 5.27 |
| Open Hearth Furnace | 1,660 | 8.74 |
| Basic Oxygen Furnace | 1,060 | 5.58 |
| Electric Arc Furnace | 620 | 3.26 |
| Gray Iron Foundry | | |
| Cupola | 2,770 | 14.58 |
| Ferro-Alloy Preparation | | |
| Blast Furnace | 1,113 | 5.86 |
| Electric Furnace | 3,669 | 19.32 |
| Non-Ferrous Alloy Preparation | | |
| Furnaces | 60 | 0.32 |
| Material Handling | NEG | NEG |
| Silico Manganese Preparation | | |
| Electric Furnace | 4,164 | 21.92 |
| Manganese Chemical Preparation | 300 | 1.58 |
| Dry Storage Battery Production | 90 | 0.47 |
| Welding Rod Production | 24 | 0.13 |
| Sewage and Sludge Burning | 175 | 0.92 |
| Power Plant Boilers | | |
| Pulverized Coal | 1,409 | 7.42 |
| Stoker Coal | 162 | 0.85 |
| Cyclone Coal | 49 | 0.26 |
| All Oil | 2 | 0.01 |
| Industrial Boilers | | |
| Pulverized Coal | 62 | 0.33 |
| Stoker Coal | 218 | 1.15 |
| Cyclone Coal | 31 | 0.16 |
| All Oil | 2 | 0.01 |
| Residential/Commercial Boilers | | |
| Coal | 20 | 0.11 |
| Oil | 3 | 0.02 |
| TOTAL | 18,993 | 100.10 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

## MERCURY

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Mercury Mining | 3 | 0.33 |
| Chlorine Fluxing, Non-Ferrous Metals | 55 | 6.94 |
| Secondary Mercury | 11 | 1.39 |
| Pulp and Paper Industry | NEG | NEG |
| Organic Chlorine Chemical Preparation | 70 | 8.86 |
| Paint, Varnish, Lacquer Production | 1 | 0.13 |
| Instrument Manufacture | 3 | 0.33 |
| Electrical Apparatus Manufacture | 3 | 0.38 |
| Dental Preparations Manufacture | 1 | 0.15 |
| Use of Pesticides, Herbicides, Fungicides | 19 | 2.40 |
| Use of Pharmaceuticals | 3 | 0.33 |
| Laboratory Use of Mercury | 51 | 6.44 |
| Consumption of Paint | 215 | 27.15 |
| Incinerators | 135 | 17.04 |
| Sewage and Sludge Burning | 11 | 1.39 |
| Power Plant Boilers | | |
| Pulverized Coal | 150 | 18.94 |
| Stoker Coal | 17 | 2.15 |
| Cyclone Coal | 6 | 0.76 |
| All Oil | 1 | 0.13 |
| Industrial Boilers | | |
| Pulverized Coal | 6 | 0.76 |
| Stoker Coal | 23 | 2.90 |
| Cyclone Coal | 3 | 0.38 |
| All Oil | 1 | 0.13 |
| Residential/Commercial Boilers | | |
| Coal | 2 | 0.25 |
| Oil | 3 | 0.38 |
| TOTAL | 792 | |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

## NICKEL

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Nickel Mining | 2 | 0.03 |
| Iron and Steel | | |
| Blast Furnace | 100 | 1.67 |
| Gray Iron Foundry | | |
| Cupola | 79 | 1.32 |
| Ferro-Alloys | | |
| Blast Furnace | 491 | 8.20 |
| Electric Furnace | 98 | 1.64 |
| Non-Ferrous Alloys | | |
| Furnaces | 64 | 1.07 |
| Material Handling | NEG | NEG |
| Power Plant Boilers | | |
| Pulverized Coal | 87 | 1.45 |
| Stoker Coal | 10 | 0.17 |
| Cyclone Coal | 3 | 0.05 |
| All Oil | 1,441 | 24.08 |
| Industrial Boilers | | |
| Pulverized Coal | 7 | 0.12 |
| Stoker Coal | 23 | 0.38 |
| Cyclone Coal | 3 | 0.05 |
| All Oil | 1,139 | 19.03 |
| Residential/Commercial | | |
| Coal | 3 | 0.05 |
| Oil | 2,435 | 40.69 |
| TOTAL | 5,985 | 100.00 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES[1]

### POM

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Iron and Steel | | |
| Metallurgical Coke | 43,380 | 0.90 |
| Asphalt Industry | | |
| Paving Material Preparation | 2,800 | 0.06 |
| Roofing Material Preparation | 23,230 | 0.48 |
| Petroleum Refining | 2,170 | 0.05 |
| Incineration | | |
| Industrial | 2,228 | 0.05 |
| Domestic | 730 | 0.02 |
| Auto Body | 14,602 | 0.30 |
| Conical Burner | 212,211 | 4.42 |
| Open Burning | 526,843 | 10.98 |
| Agricultural Burning | 2,161,142 | 45.05 |
| Natural Fires, Forest | 1,433,712 | 29.89 |
| Natural Fires, Urban | 6,060 | 0.13 |
| Municipal | 682 | 0.01 |
| Coal Refuse | 193,500 | 4.03 |
| Power Plant Boilers | | |
| Pulverized Coal | 8,980 | 0.19 |
| Stoker Coal | 1,032 | 0.02 |
| Cyclone Coal | 310 | 0.01 |
| All Oil | 7,675 | 0.16 |
| All Gas | 6,151 | 0.13 |
| Industrial Boilers | | |
| Pulverized Coal | 1,896 | 0.04 |
| Stoker Coal | 6,635 | 0.14 |
| Cyclone Coal | 948 | 0.02 |
| All Oil | 10,001 | 0.21 |
| All Gas | 20,220 | 0.42 |
| Residential/Commercial | | |
| Coal | 66,796 | 1.39 |
| Oil | 33,105 | 0.69 |
| Gas | 10,065 | 0.21 |
| TOTAL | 4,797,104 | 100.00 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### SELENIUM

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Primary Copper | | |
| Roasting | 17 | 1.99 |
| Reverberatory Furnace | 8 | 0.94 |
| Converters | 22 | 2.57 |
| Material Handling | 5 | 0.59 |
| Primary Zinc | | |
| Roasting | 27 | 3.16 |
| Primary Lead | | |
| Sintering | 5 | 0.59 |
| Blast Furnace | 2 | 0.23 |
| Secondary Copper, Zinc, Lead | 1 | 0.12 |
| Glass Manufacture | 203 | 23.74 |
| Paint, Varnish, Lacquer Manufacture | 1 | 0.12 |
| Incineration | 1 | 0.12 |
| Power Plant Boilers | | |
| Pulverized Coal | 360 | 42.11 |
| Stoker Coal | 41 | 4.80 |
| Cyclone Coal | 12 | 1.40 |
| All Oil | 19 | 2.22 |
| Industrial Boilers | | |
| Pulverized Coal | 16 | 1.87 |
| Stoker Coal | 56 | 6.55 |
| Cyclone Coal | 8 | 0.94 |
| All Oil | 14 | 1.64 |
| Residential/Commercial Boilers | | |
| Coal | 5 | 0.59 |
| Oil | 32 | 3.74 |
| TOTAL | 855 | 100.03 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### TIN

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Iron and Steel | | |
| Open Hearth | 260 | 73.03 |
| Power Plant Boilers | | |
| Pulverized Coal | 68 | 19.10 |
| Stoker Coal | 8 | 2.25 |
| Cyclone Coal | 2 | 0.56 |
| Industrial Boilers | | |
| Pulverized Coal | 3 | 0.84 |
| Stoker Coal | 11 | 3.09 |
| Cyclone Coal | 2 | 0.56 |
| Residential/Commercial | | |
| Coal | 1 | 0.28 |
| All Boilers, Oil | 1 | 0.28 |
| TOTAL | 356 | 99.99 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES (1)

### VANADIUM

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Vanadium Refining | 81 | 0.45 |
| Iron and Steel | | |
| Blast Furnace | 63 | 0.35 |
| Open Hearth Furnace | 166 | 0.93 |
| Basic Oxygen Furnace | 7 | 0.04 |
| Gray Iron Foundry | | |
| Cupola | 1 | 0.01 |
| Ferro-Alloys | | |
| Electric Furnace | 115 | 0.64 |
| Material Handling | 29 | 0.16 |
| Non-Ferrous Alloys | | |
| Furnaces | 3 | 0.02 |
| Vanadium Chemical Preparation | 4 | 0.02 |
| Ceramic Coating Preparation | NEG | NEG |
| Power Plant Boilers | | |
| Pulverized Coal | 1,013 | 5.67 |
| Stoker Coal | 116 | 0.65 |
| Cyclone Coal | 35 | 0.20 |
| All Oil | 4,930 | 27.58 |
| Industrial Boilers | | |
| Pulverized Coal | 45 | 0.25 |
| Stoker Coal | 158 | 0.88 |
| Cyclone Coal | 23 | 0.13 |
| All Oil | 2,740 | 15.33 |
| Residential/Commercial Boilers | | |
| Coal | 14 | 0.08 |
| Oil | 8,330 | 46.61 |
| TOTAL | 17,873 | 100.00 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

## HAZARDOUS POLLUTANT SOURCES

### ZINC (Continued)

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Industrial Boilers | | |
| Pulverized Coal | 109 | 0.07 |
| Stoker Coal | 382 | 0.25 |
| Cyclone Coal | 55 | 0.04 |
| All Oil | 99 | 0.07 |
| Residential/Commercial Boilers | | |
| Coal | 34 | 0.02 |
| Oil | 221 | 0.15 |
| TOTAL | 150,656 | 100.04 |

## HAZARDOUS POLLUTANT SOURCES (1)

### ZINC

| Source | Amount in Tons | % This Pollutant |
|---|---|---|
| Zinc Mining | 72 | 0.05 |
| Primary Zinc | | |
| Roasting | 31,818 | 21.13 |
| Sintering | 13,637 | 9.05 |
| Distillation | 4,545 | 3.02 |
| Zinc Oxide Production | 8,100 | 5.38 |
| Secondary Copper | | |
| Wire Burning | 135 | 0.09 |
| Sweating Furnace | 14 | 0.01 |
| Blast Furnace | 14 | 0.01 |
| Smelting, Reverberatory Furnace | 14 | 0.01 |
| Smelting, Rotary Furnace | 3 | NEG |
| Secondary Zinc | | |
| Sweating Furnaces | 2,890 | 1.92 |
| Distillation Furnaces | 950 | 0.63 |
| Iron and Steel | | |
| Blast Furnace | 1,070 | 0.71 |
| Open Hearth Furnace | 39,000 | 25.89 |
| Basic Oxygen Furnace | 900 | 0.60 |
| Electric Arc Furnace | 7,400 | 4.91 |
| Gray Iron Foundry | | |
| Cupola | 1,700 | 1.13 |
| Ferro-Alloys | | |
| Blast Furnace | 2,500 | 1.66 |
| Electric Furnace | 500 | 0.33 |
| Material Handling | NEG | NEG |
| Zinc Galvanizing | 950 | 0.63 |
| Zinc Chemical Preparation | 1,130 | 0.75 |
| Paint, Varnish, Lacquer Manufacture | 10 | 0.01 |
| Incineration | 29,450 | 19.55 |
| Power Plant Boilers | | |
| Pulverized Coal | 2,457 | 1.63 |
| Stoker Coal | 282 | 0.19 |
| Cyclone Coal | 85 | 0.06 |
| All Oil | 130 | 0.09 |

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(1) Source: The MITRE Corporation
Preliminary Results
EPA Contract No. 68-01-0438

# APPENDIX B

## HAZARDS ASSOCIATED WITH CANDIDATE POLLUTANTS

In varying degrees, all of the pollutant candidates discussed herein may contribute to illness or death. Consequently it is reasonable to anticipate that, particularly the more dangerous of these may be dealt with as hazardous air pollutants as defined by the Clean Air Act.

Section 112 of the Clean Air Act Amendments of 1970 defines a hazardous air pollutant as one "to which no ambient air quality standard is applicable and which in the judgment of the Administrator may cause or contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness." For those substances which the Administrator chooses to classify as hazardous, the law states that he shall "establish any such standard at the level which in his judgement provides an ample margin of safety to protect the public health from such hazardous air pollutant."

Herein lies a matter of considerable impact. To ascertain whether standards to be applied provide any safety margin it is necessary to know, at least in approximate terms, where lies the level of incipient hazard. This information is not generally known in sufficiently useful detail although the literature on health effects and toxicity of specific substances is large. In an effort to assist EPA in determining hazard levels, the National Academy of Sciences is preparing a series of documents on selected pollutants. Certain other summary documents are available.

Those that have been published to date include the following substances:

| | |
|---|---|
| Beryllium | Lead |
| Mercury | Fluorides |
| Asbestos | Cadmium |

The current status of information concerning other pollutants is as follows:

| | |
|---|---|
| Nickel<br>Vanadium<br>Manganese<br>Chromium | First draft of NAS Report in preparation |
| POM (BaP) | NAS Report on Order |
| Zinc<br>Chlorine<br>Copper | Current Year Studies Available in about 15 Months |
| Arsenic | Report expected Mid-FY 73 |

Some of the basic portions and conclusions concerning the hazardous potential of pollutants concerning which documents have issued are now summarized.

## Mercury, Beryllium and Asbestos

The health hazards presented by each of these three substances are reviewed in a document[1] released by EPA as background for proposed national emission standards. Specific serious illnesses have been associated with each. For mercury and beryllium specific ambient air concentrations have been identified so that with the aid of dispersion models emission standards could be set.

Although no quantitative air quality standards could be set for asbestos, the results of epidemiological and other studies prompted a decision to propose a standard calling for the greatest practicable degree of control over all asbestos emissions.

## Lead

### Extent of Pollution

The NAS Report on lead[2] concludes that there has been substantial lead contamination of the total environment, i.e. air, soil, and water. The larger portion of this has been contributed by the lead-using industries rather than by automobile emissions. However, the results of an APCO survey of emissions in 1968 reveal that only 2% of the lead emitted directly to the atmosphere comes from the industrial sources, while the remainder is from burned lead alkyls. Moreover, it has been found that the concentration of lead in ambient air correlated with the density of automobile traffic. Urban airborne lead concentrations were higher than concentrations in rural areas, with the larger cities showing higher values than the smaller.

| Emission Source | Lead Emitted, Tons/Year |
|---|---|
| Gasoline combustion | 181,000 |
| Coal combustion | 920 |
| Fuel oil combustion | 24 |
| Lead alkyl manufacturing | 810 |
| Primary lead smelting | 174 |
| Secondary lead smelting | 811 |
| Brass manufacturing | 521 |
| Lead oxide manufacturing | 20 |
| Gasoline transfer | 36 |
| Total | 184,316 |

Generally, lead concentrations decrease rapidly with distance from the source although the smaller particles (< 2μ in diameter) can remain in the atmosphere for long periods of time and can become widely dispersed. In fact, it is a consequence of this dispersive effect that the urban air concentrations of lead has been increasing only slowly over the long term.

Our concern is with that portion of the airborne lead emanating from stationary sources. Although this represents only an estimated 2% of the total in this category the amount of material in question is in excess of 3,000 tons/year much of which comes from a relatively few locations so that local conditions may be found which require correction. A case in point is represented by lead smelters, in whose vicinity very high levels of lead have been found both in the air and in the soil[3].

The NAS report devotes considerable space to documentation of the deleterious effects of ingested lead on humans[5] and animals[4] leaving no doubt as to the dangers involved. Although a number of sources of lead poisoning were described by the report, it was generally concluded that for the bulk of the population lead in the air posed no identifiable threat[6]. However it is possible that the combined effects of normal intake levels in food and water and abnormal concentrations in the air can create hazardous circumstances.

Thus, the NAS reports[6] that in urban settings, man is "...possibly exposed to hazardous circumstances relative to atmospheric lead pollution, occupational exposures in the lead-using industries excepted. The high concentrations of lead in urban air and on the surfaces of parks and streets constitute a source of intake additional to the usual dietary sources and in special circumstances may be a substantial source."

Any further increase in lead concentrations caused by local industrial sources would add to the already high rates of intake and thereby increasing the body burden of lead, and contributing to short and long term adverse health effects. Accordingly, the prospect of standards for and controls over lead emissions is a likely one so that sources of lead emissions merit would rank high among the candidates for consideration under the control technology programs.

## Fluorides

### Evaluation of Hazard

The NAS report on fluorides[8] presents the following general conclusion[9].

> "It is evident that the more important aspect of fluoride in the ambient air is its effect on vegetation and its accumulation in forage in amounts that lead to harmful effects in cattle and other animals. A comparison of current levels of fluorides in the community atmosphere with the concentrations required for injury to vegetation and cattle suggests that the hazard to these receptors is limited to particular areas.
>
> Current knowledge indicates that air borne fluoride presents no direct hazard to man, except in industrial exposure. However, through the commercial, aesthetic, and ecologic functions of plants, fluoride in the environment may indirectly influence man's health and well being."

Also, the indication is given[10] that airborne fluoride concentrations which do not affect plant life offer no threat to human life. However, fluoride pollution may result in severe damage to crops and other plant life as well as to animals feeding on contaminated vegetation[11]. A number of instances are cited documenting cases of damage from airborne fluorides in the vicinity of phosphate mining operations and aluminum manufacturing operations.

## Cadmium

Exposure to cadmium oxide fumes and dust have been responsible for incidences of emphysema, bronchitis and general lung damage.[12] Cadmium in food or beverages has been responsible for cases of acute poisoning[13]. Long-term exposure to CdO fumes and dust will result in kidney damage and consequent damage to bone structure. Other adverse effects of long-term exposure which have been noted are anemia and liver disfunction.

One manifestation of chronic cadmium poisoning is the Itai-Pitai disease found among Japanese. The main cause of this disease is contamination of rice probably as a consequence of irrigation with river water heavily contaminated by Cadmium[15]. It is also suspected that Cadmium is carcinogenic in humans[14]. However, further evidence is required to prove this point.

Cadmium in the environment is a particularly serious hazard because cadmium will accumulate in the body. For example, the "standard man" in the U.S. accumulates about 30 mg. of Cd over a 50 year period.

Absorption occurs primarily directly from the lungs which retain between 10 and 40 percent of the inhaled cadmium. The total amount retained depends in large measure on particle size distribution and obviously on the concentration level as well. In areas around cadmium emitting factories the concentrations will be several hundred times greater than those found elsewhere[17].

# APPENDIX B

## REFERENCES

[1] Background Information - Proposed National Emission Standards for Hazardous Air Pollutants: Asbestos, Beryllium, Mercury EPA, OAP, RTP, N.C. 12/71 (NTIS:PB 204876)

[2] Biologic Effects of Atmospheric Pollutants: Lead (Airborne Lead in Perspective) NAS Washington D.C. 1972

[3] R.E. Engel, et al., Environmental Lead and Public Health APCO, RTP, EPA, March 1971

[4] NAS Lead Document - Chapter 4

[5] ibid. Chapter 5

[6] ibid. p. 209

[7] ibid. pp.104-144

[8] Biologic Effects of Atmospheric Pollutants: Fluorides National Academy of Sciences, Washington D.C. 1971

[9] ibid. p. 240

[10] ibid. p. 221

[11] ibid. pp. 34-41

[12] Lou Friberg, et al., Cadmium in the Environment. A Toxicological and Epidemiological Approval. Karolenska Institute, Stockholm, Sweden, April 1971

[13] ibid. Chapter 6

[14] ibid. Chapter 7

[15] ibid. Chapter 8

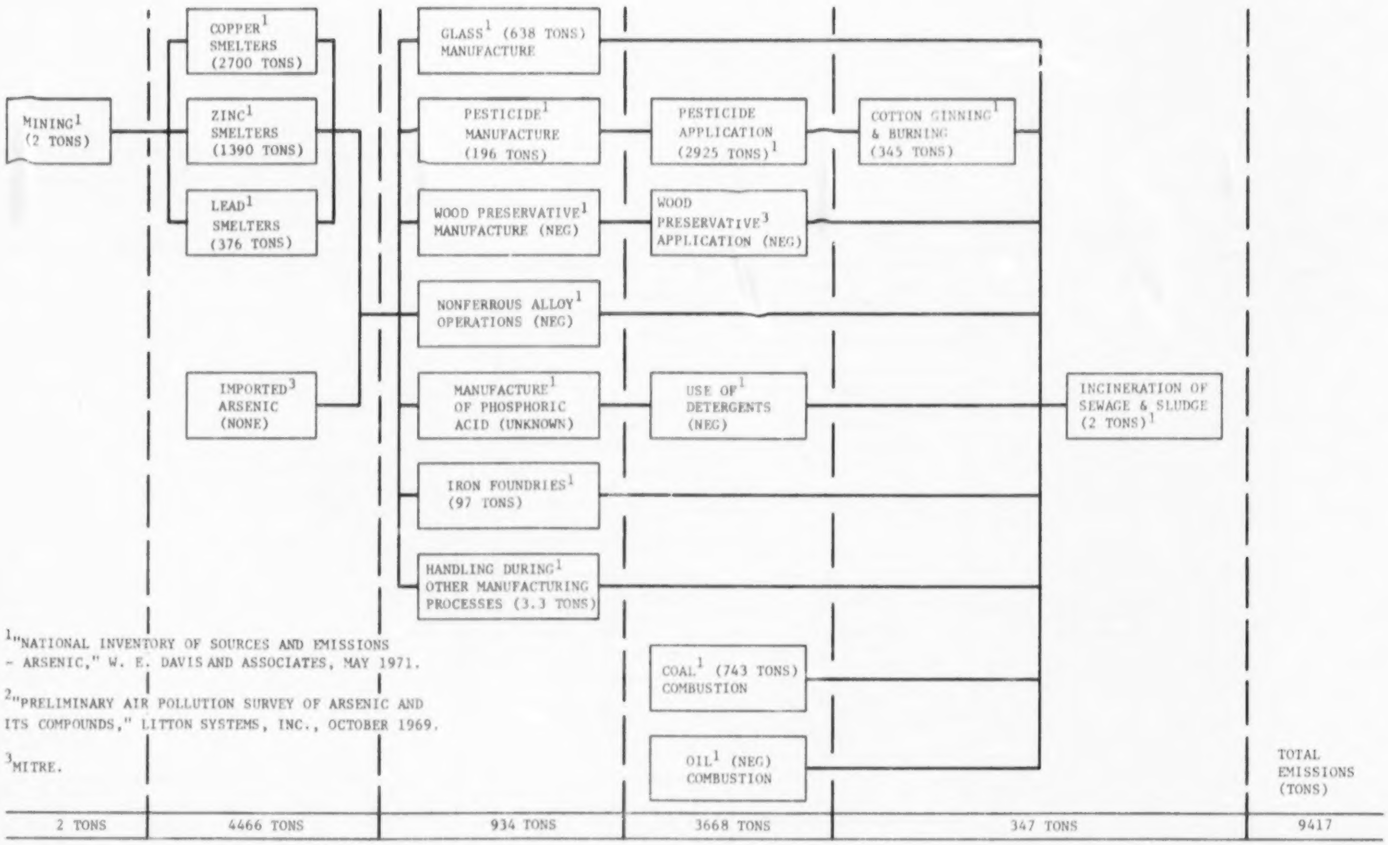
[16] ibid. Chapter 6

[17] ibid. p. 3-3

# APPENDIX C

## MATERIAL FLOWS THROUGH THE ECONOMY

This section contains flow charts prepared by The MITRE Corporation for each of the pollutant candidates showing the paths of each through the economy from mining through end use and waste disposal. The primary emission sources are shown as are the estimated magnitudes at each point in the process. This material was assembled during the course of the work and is included here as a useful reference.

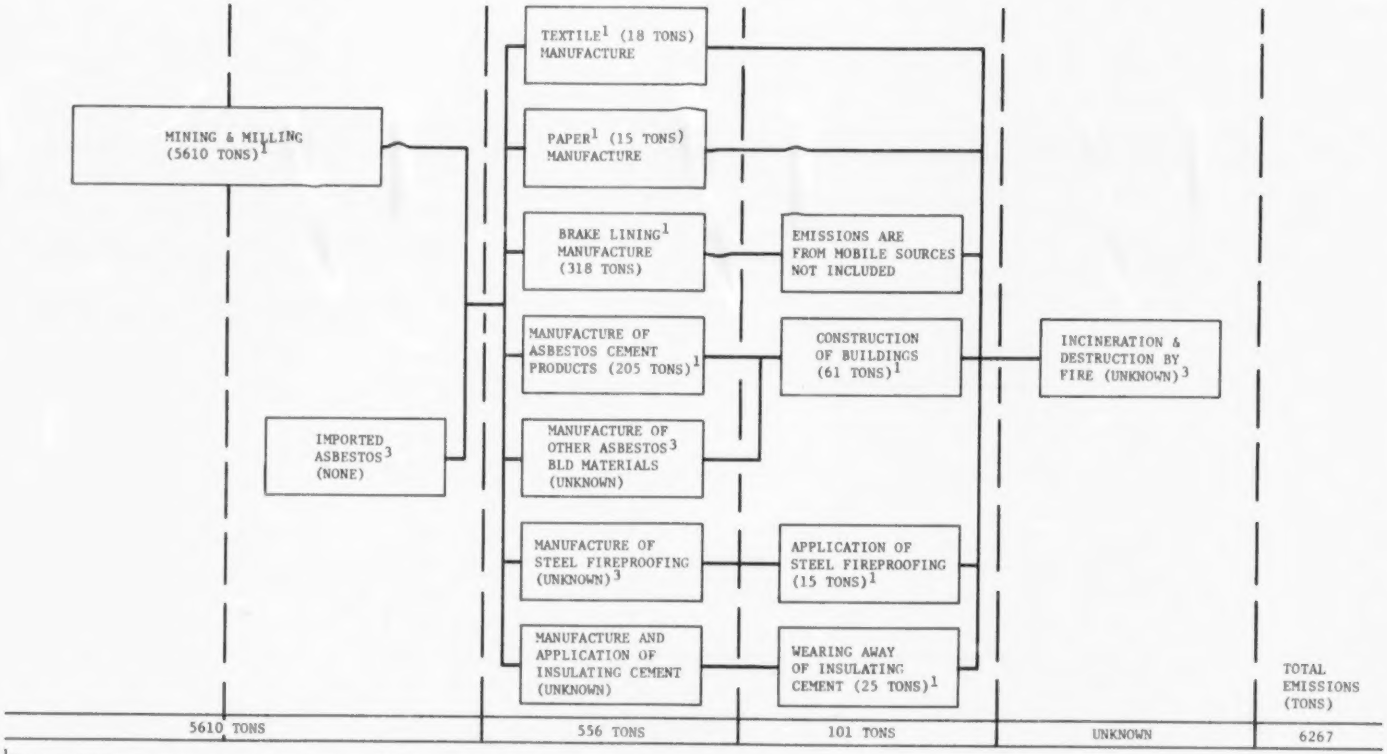

MINING[1] (2 TONS)
COPPER[1] SMELTERS (2700 TONS)
ZINC[1] SMELTERS (1390 TONS)
LEAD[1] SMELTERS (376 TONS)
IMPORTED[3] ARSENIC (NONE)
GLASS[1] (638 TONS) MANUFACTURE
PESTICIDE[1] MANUFACTURE (196 TONS)
WOOD PRESERVATIVE[1] MANUFACTURE (NEG)
NONFERROUS ALLOY[1] OPERATIONS (NEG)
MANUFACTURE[1] OF PHOSPHORIC ACID (UNKNOWN)
IRON FOUNDRIES[1] (97 TONS)
HANDLING DURING[1] OTHER MANUFACTURING PROCESSES (3.3 TONS)
PESTICIDE APPLICATION (2925 TONS)[1]
WOOD PRESERVATIVE[3] APPLICATION (NEG)
USE OF[1] DETERGENTS (NEG)
COAL[1] (743 TONS) COMBUSTION
OIL[1] (NEG) COMBUSTION
COTTON GINNING[1] & BURNING (345 TONS)
INCINERATION OF SEWAGE & SLUDGE (2 TONS)[1]
TOTAL EMISSIONS (TONS)
2 TONS
4466 TONS
934 TONS
3668 TONS
347 TONS
9417

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - ARSENIC," W. E. DAVIS AND ASSOCIATES, MAY 1971.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF ARSENIC AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- ARSENIC -

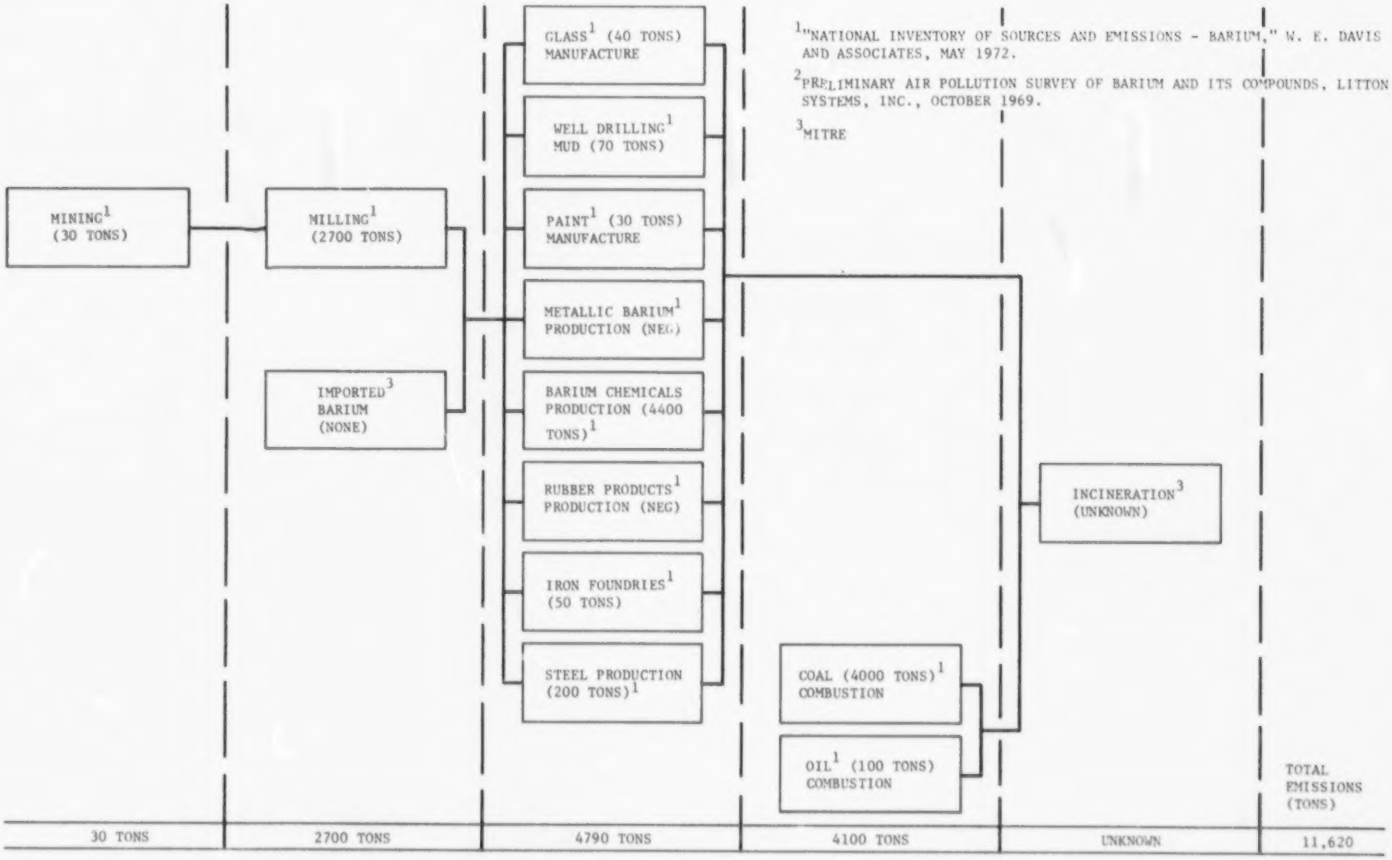

MINING & MILLING (5610 TONS)1
IMPORTED ASBESTOS3 (NONE)
TEXTILE1 (18 TONS) MANUFACTURE
PAPER1 (15 TONS) MANUFACTURE
BRAKE LINING1 MANUFACTURE (318 TONS)
MANUFACTURE OF ASBESTOS CEMENT PRODUCTS (205 TONS)1
MANUFACTURE OF OTHER ASBESTOS3 BLD MATERIALS (UNKNOWN)
MANUFACTURE OF STEEL FIREPROOFING (UNKNOWN)3
MANUFACTURE AND APPLICATION OF INSULATING CEMENT (UNKNOWN)
EMISSIONS ARE FROM MOBILE SOURCES NOT INCLUDED
CONSTRUCTION OF BUILDINGS (61 TONS)1
APPLICATION OF STEEL FIREPROOFING (15 TONS)1
WEARING AWAY OF INSULATING CEMENT (25 TONS)1
INCINERATION & DESTRUCTION BY FIRE (UNKNOWN)3
TOTAL EMISSIONS (TONS)
5610 TONS
556 TONS
101 TONS
UNKNOWN
6267

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - ASBESTOS," W. E. DAVIS AND ASSOCIATES, FEBRUARY 1970.

[2] PRELIMINARY AIR POLLUTION SURVEY OF ASBESTOS, LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- ASBESTOS -

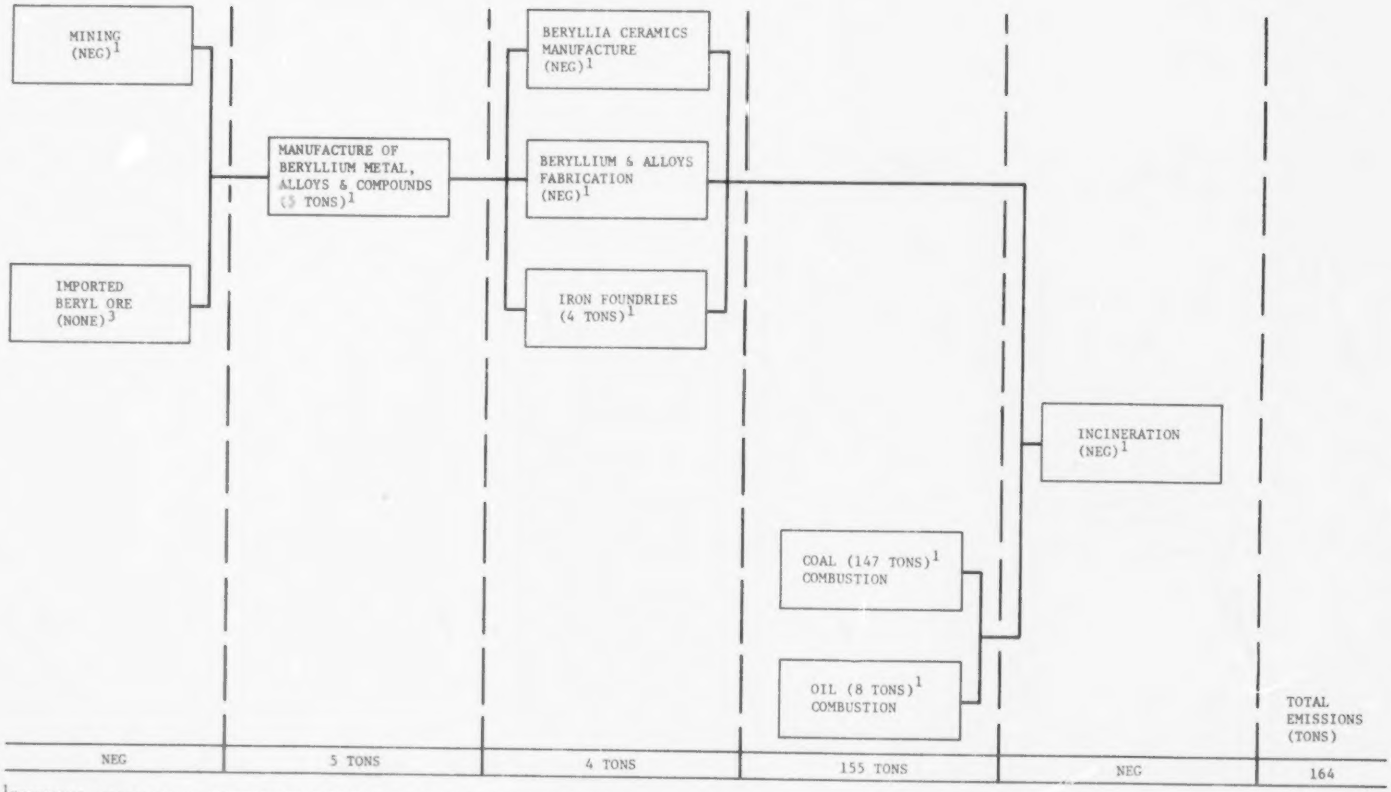

MINING[1]
(30 TONS)
MILLING[1]
(2700 TONS)
IMPORTED[3]
BARIUM
(NONE)
GLASS[1] (40 TONS)
MANUFACTURE
WELL DRILLING[1]
MUD (70 TONS)
PAINT[1] (30 TONS)
MANUFACTURE
METALLIC BARIUM[1]
PRODUCTION (NEG)
BARIUM CHEMICALS
PRODUCTION (4400
TONS)[1]
RUBBER PRODUCTS[1]
PRODUCTION (NEG)
IRON FOUNDRIES[1]
(50 TONS)
STEEL PRODUCTION
(200 TONS)[1]
COAL (4000 TONS)[1]
COMBUSTION
OIL[1] (100 TONS)
COMBUSTION
INCINERATION[3]
(UNKNOWN)
TOTAL
EMISSIONS
(TONS)
30 TONS
2700 TONS
4790 TONS
4100 TONS
UNKNOWN
11,620

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - BARIUM," W. E. DAVIS AND ASSOCIATES, MAY 1972.

[2] PRELIMINARY AIR POLLUTION SURVEY OF BARIUM AND ITS COMPOUNDS, LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- BARIUM -

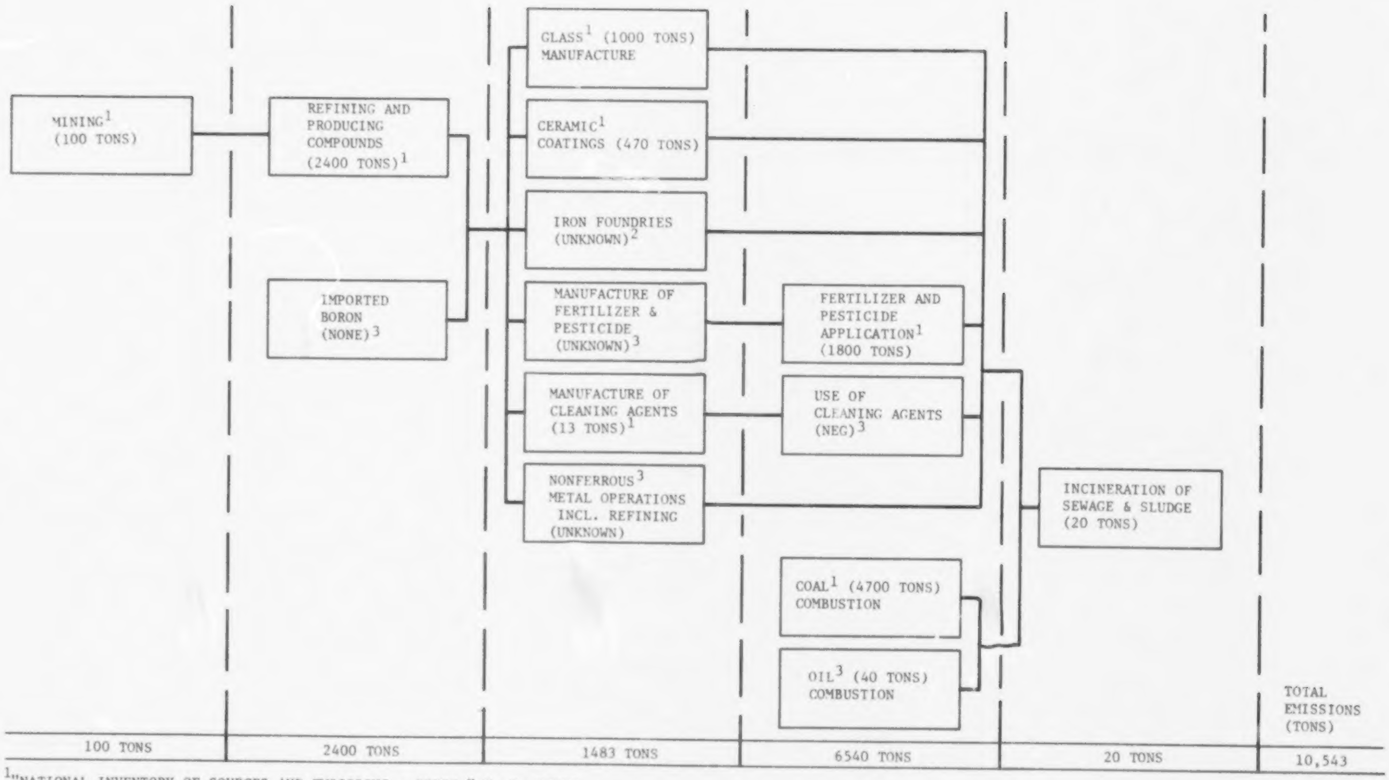

MINING
(NEG)1
IMPORTED
BERYL ORE
(NONE)3
MANUFACTURE OF
BERYLLIUM METAL,
ALLOYS & COMPOUNDS
(5 TONS)1
BERYLLIA CERAMICS
MANUFACTURE
(NEG)1
BERYLLIUM & ALLOYS
FABRICATION
(NEG)1
IRON FOUNDRIES
(4 TONS)1
COAL (147 TONS)1
COMBUSTION
OIL (8 TONS)1
COMBUSTION
INCINERATION
(NEG)1
TOTAL
EMISSIONS
(TONS)
NEG
5 TONS
4 TONS
155 TONS
NEG
164

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - BERYLLIUM," W. E. DAVIS AND ASSOCIATES, SEPTEMBER 1971.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF BERYLLIUM AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- BERYLLIUM -

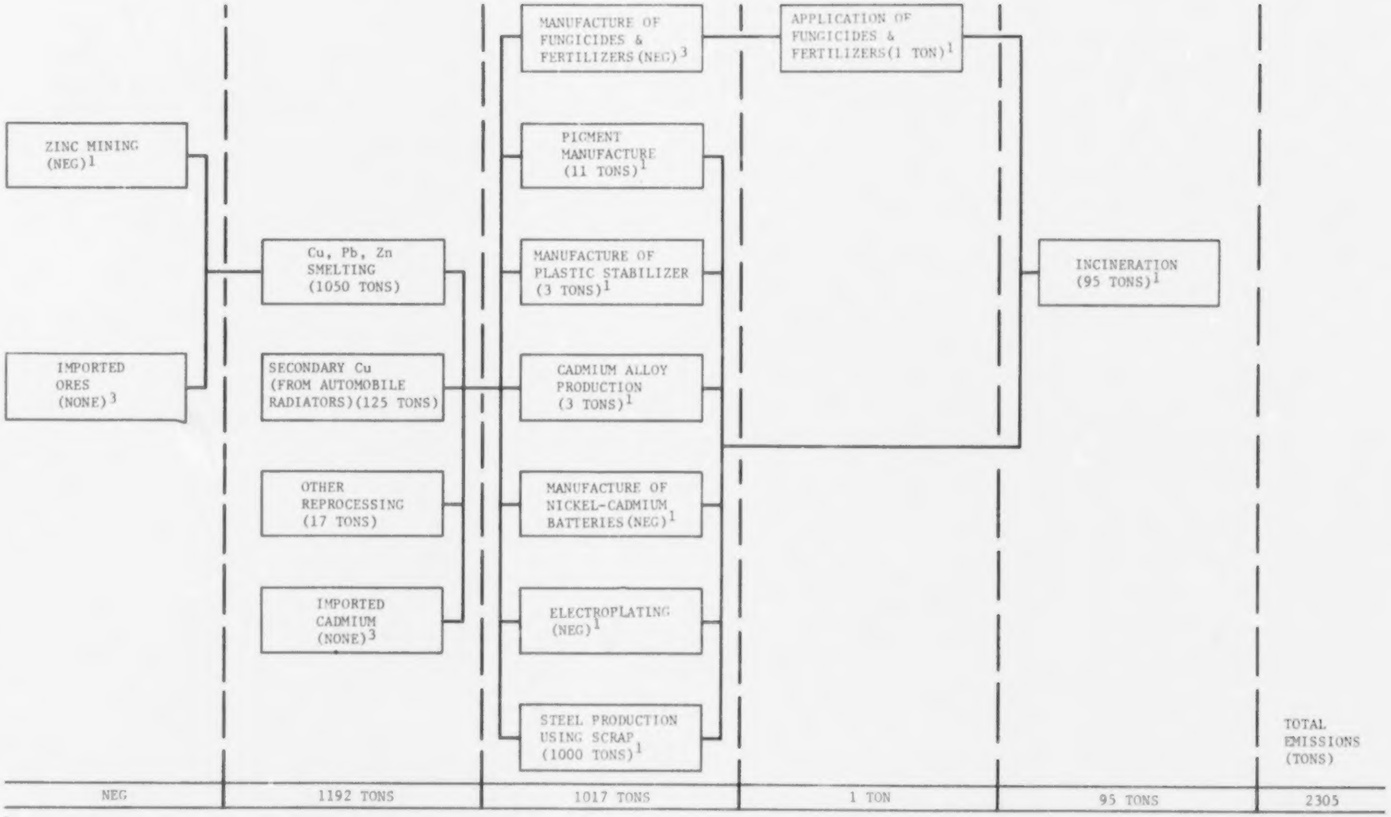

MINING1 (100 TONS)
REFINING AND PRODUCING COMPOUNDS (2400 TONS)1
IMPORTED BORON (NONE)3
GLASS1 (1000 TONS) MANUFACTURE
CERAMIC1 COATINGS (470 TONS)
IRON FOUNDRIES (UNKNOWN)2
MANUFACTURE OF FERTILIZER & PESTICIDE (UNKNOWN)3
MANUFACTURE OF CLEANING AGENTS (13 TONS)1
NONFERROUS3 METAL OPERATIONS INCL. REFINING (UNKNOWN)
FERTILIZER AND PESTICIDE APPLICATION1 (1800 TONS)
USE OF CLEANING AGENTS (NEG)3
COAL1 (4700 TONS) COMBUSTION
OIL3 (40 TONS) COMBUSTION
INCINERATION OF SEWAGE & SLUDGE (20 TONS)
TOTAL EMISSIONS (TONS)
100 TONS
2400 TONS
1483 TONS
6540 TONS
20 TONS
10,543

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - BORON," W. E. DAVIS AND ASSOCIATES, JUNE 1972.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF BORON AND ITS COMPOUNDS, LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- BORON -

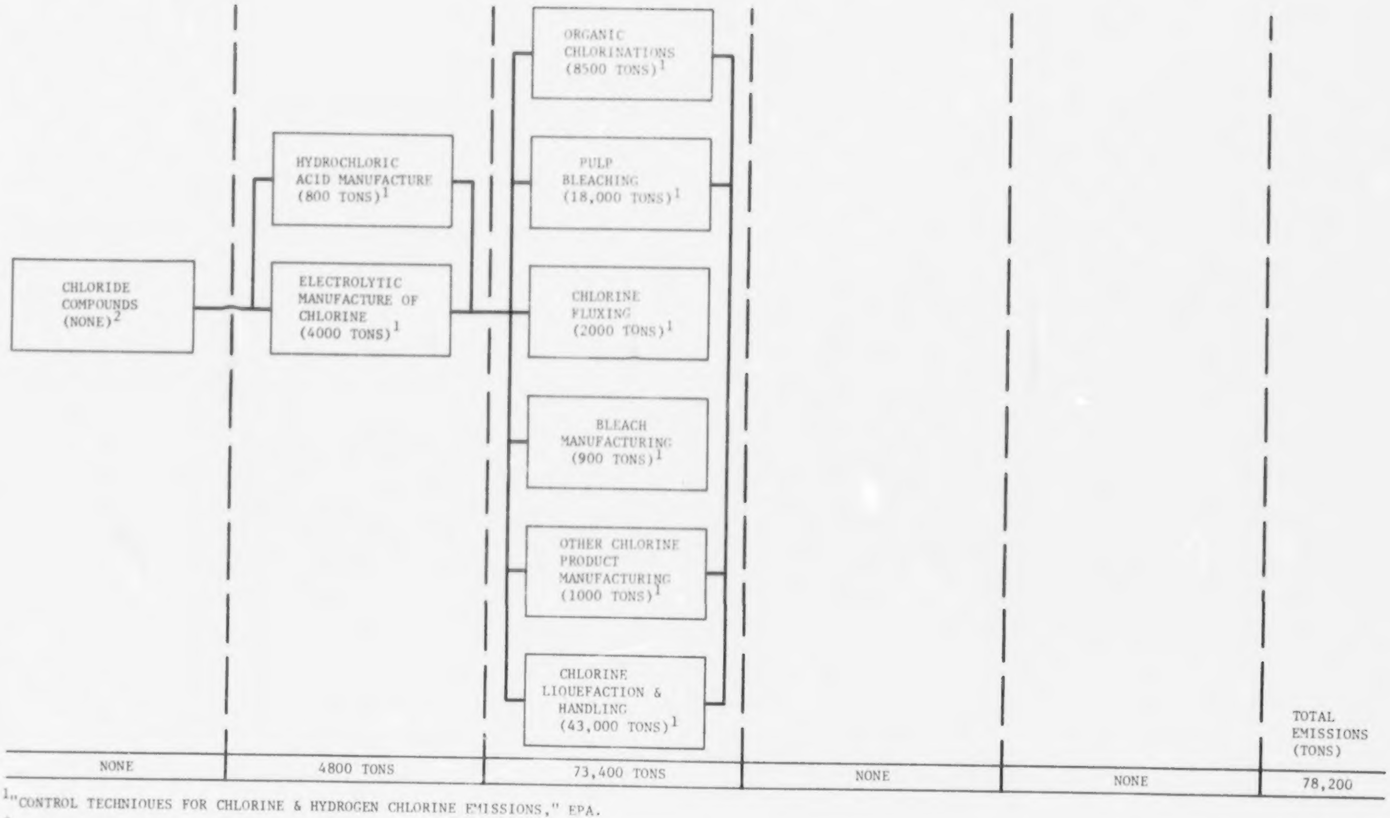

ZINC MINING (NEG)1
IMPORTED ORES (NONE)3
Cu, Pb, Zn SMELTING (1050 TONS)
SECONDARY Cu (FROM AUTOMOBILE RADIATORS)(125 TONS)
OTHER REPROCESSING (17 TONS)
IMPORTED CADMIUM (NONE)3
MANUFACTURE OF FUNGICIDES & FERTILIZERS(NEG)3
PIGMENT MANUFACTURE (11 TONS)1
MANUFACTURE OF PLASTIC STABILIZER (3 TONS)1
CADMIUM ALLOY PRODUCTION (3 TONS)1
MANUFACTURE OF NICKEL-CADMIUM BATTERIES(NEG)1
ELECTROPLATING (NEG)1
STEEL PRODUCTION USING SCRAP (1000 TONS)1
APPLICATION OF FUNGICIDES & FERTILIZERS(1 TON)1
INCINERATION (95 TONS)1
TOTAL EMISSIONS (TONS)
NEG
1192 TONS
1017 TONS
1 TON
95 TONS
2305

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - CADMIUM, W. E. DAVIS AND ASSOCIATES," FEBRUARY 1970.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF CADMIUM AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- CADMIUM -

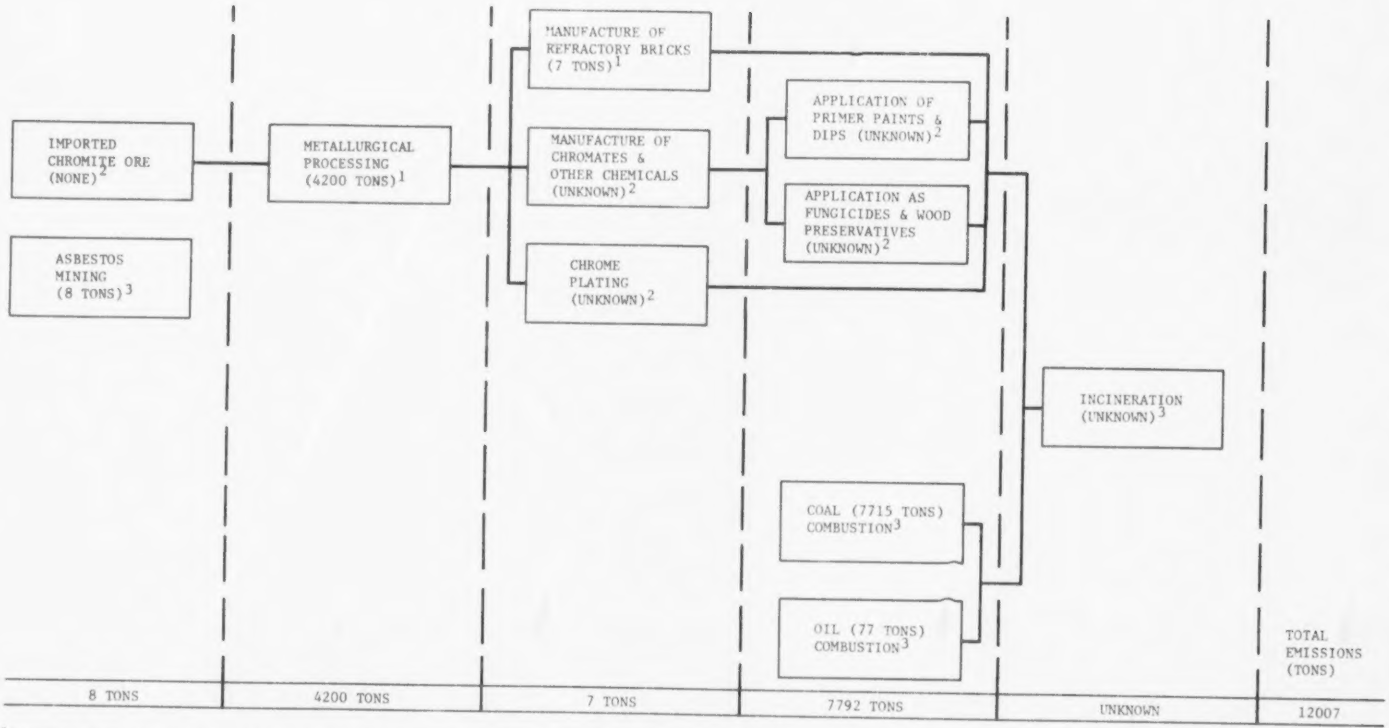

CHLORIDE COMPOUNDS (NONE)$^2$
HYDROCHLORIC ACID MANUFACTURE (800 TONS)$^1$
ELECTROLYTIC MANUFACTURE OF CHLORINE (4000 TONS)$^1$
ORGANIC CHLORINATIONS (8500 TONS)$^1$
PULP BLEACHING (18,000 TONS)$^1$
CHLORINE FLUXING (2000 TONS)$^1$
BLEACH MANUFACTURING (900 TONS)$^1$
OTHER CHLORINE PRODUCT MANUFACTURING (1000 TONS)$^1$
CHLORINE LIQUEFACTION & HANDLING (43,000 TONS)$^1$
TOTAL EMISSIONS (TONS)
NONE
4800 TONS
73,400 TONS
NONE
NONE
78,200

[1] "CONTROL TECHNIQUES FOR CHLORINE & HYDROGEN CHLORINE EMISSIONS," EPA.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF CHLORINE GAS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- CHLORINE -

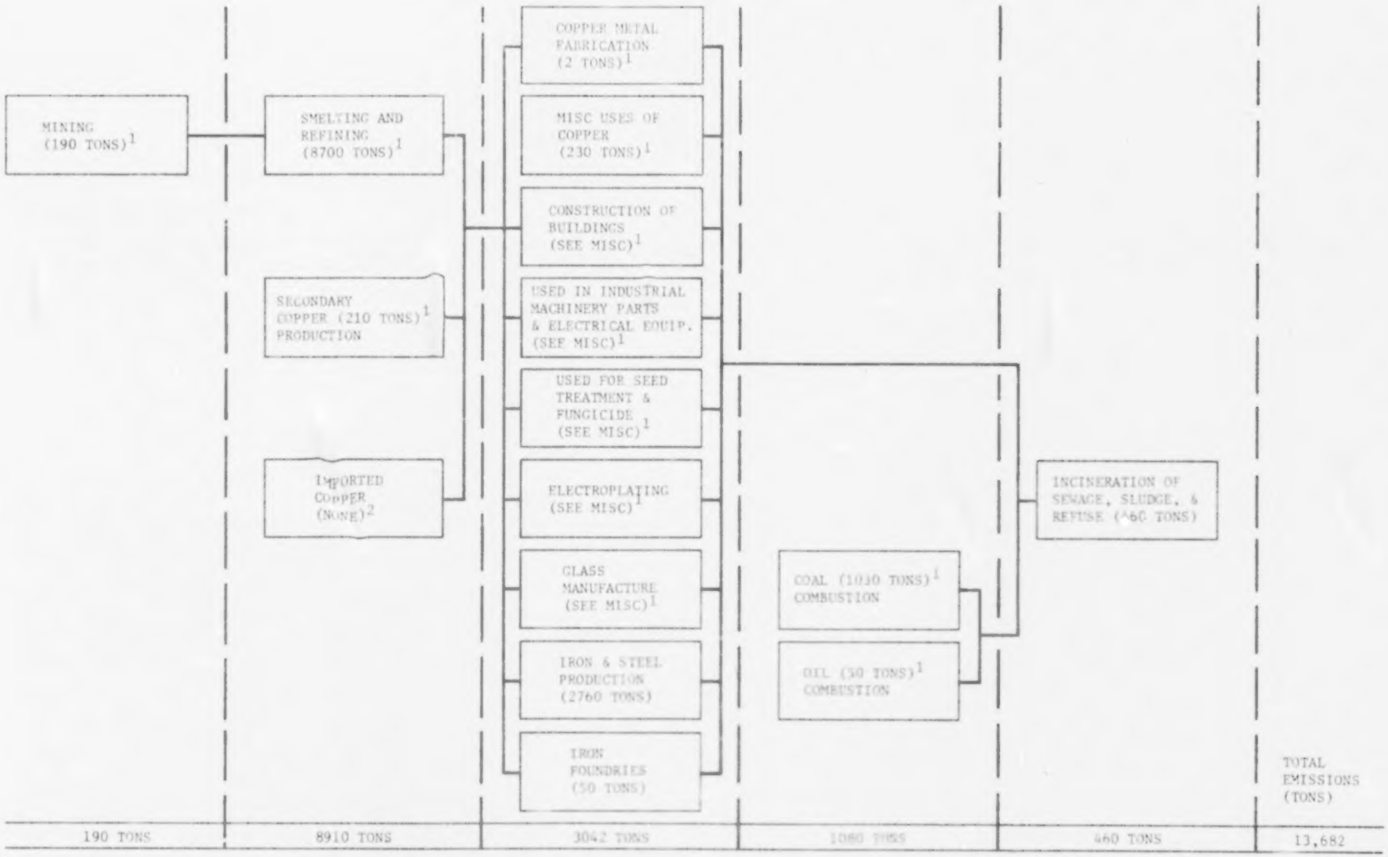

IMPORTED CHROMITE ORE (NONE)2
ASBESTOS MINING (8 TONS)3
METALLURGICAL PROCESSING (4200 TONS)1
MANUFACTURE OF REFRACTORY BRICKS (7 TONS)1
MANUFACTURE OF CHROMATES & OTHER CHEMICALS (UNKNOWN)2
CHROME PLATING (UNKNOWN)2
APPLICATION OF PRIMER PAINTS & DIPS (UNKNOWN)2
APPLICATION AS FUNGICIDES & WOOD PRESERVATIVES (UNKNOWN)2
COAL (7715 TONS) COMBUSTION3
OIL (77 TONS) COMBUSTION3
INCINERATION (UNKNOWN)3
TOTAL EMISSIONS (TONS)
8 TONS
4200 TONS
7 TONS
7792 TONS
UNKNOWN
12007

[1] "CONTROL TECHNIQUES FOR EMISSIONS CONTAINING CHROMIUM, MANGANESE, NICKEL, AND VANADIUM," BATTELLE.

[2] PRELIMINARY AIR POLLUTION SURVEY OF CHROMIUM AND ITS COMPOUNDS, LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- CHROMIUM -


MINING (190 TONS)1
SMELTING AND REFINING (8700 TONS)1
SECONDARY COPPER (210 TONS)1 PRODUCTION
IMPORTED COPPER (NONE)2
COPPER METAL FABRICATION (2 TONS)1
MISC USES OF COPPER (230 TONS)1
CONSTRUCTION OF BUILDINGS (SEE MISC)1
USED IN INDUSTRIAL MACHINERY PARTS & ELECTRICAL EQUIP. (SEE MISC)1
USED FOR SEED TREATMENT & FUNGICIDE 1 (SEE MISC)
ELECTROPLATING (SEE MISC)1
GLASS MANUFACTURE (SEE MISC)1
IRON & STEEL PRODUCTION (2760 TONS)
IRON FOUNDRIES (50 TONS)
COAL (1030 TONS)1 COMBUSTION
OIL (50 TONS)1 COMBUSTION
INCINERATION OF SEWAGE, SLUDGE, & REFUSE (460 TONS)
TOTAL EMISSIONS (TONS)
190 TONS
8910 TONS
3042 TONS
1080 TONS
460 TONS
13,682

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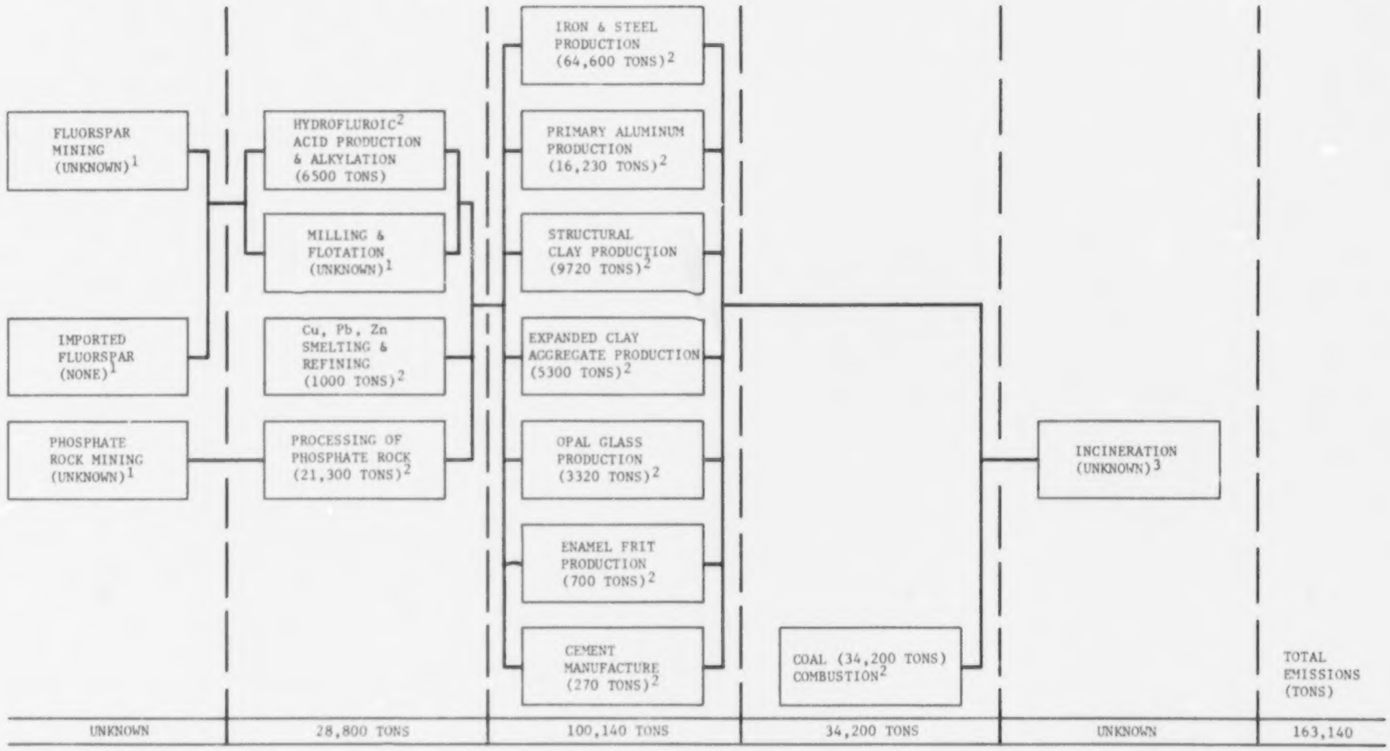
[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - COPPER," W.E. DAVIS, APRIL 1972.

[2] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- COPPER -

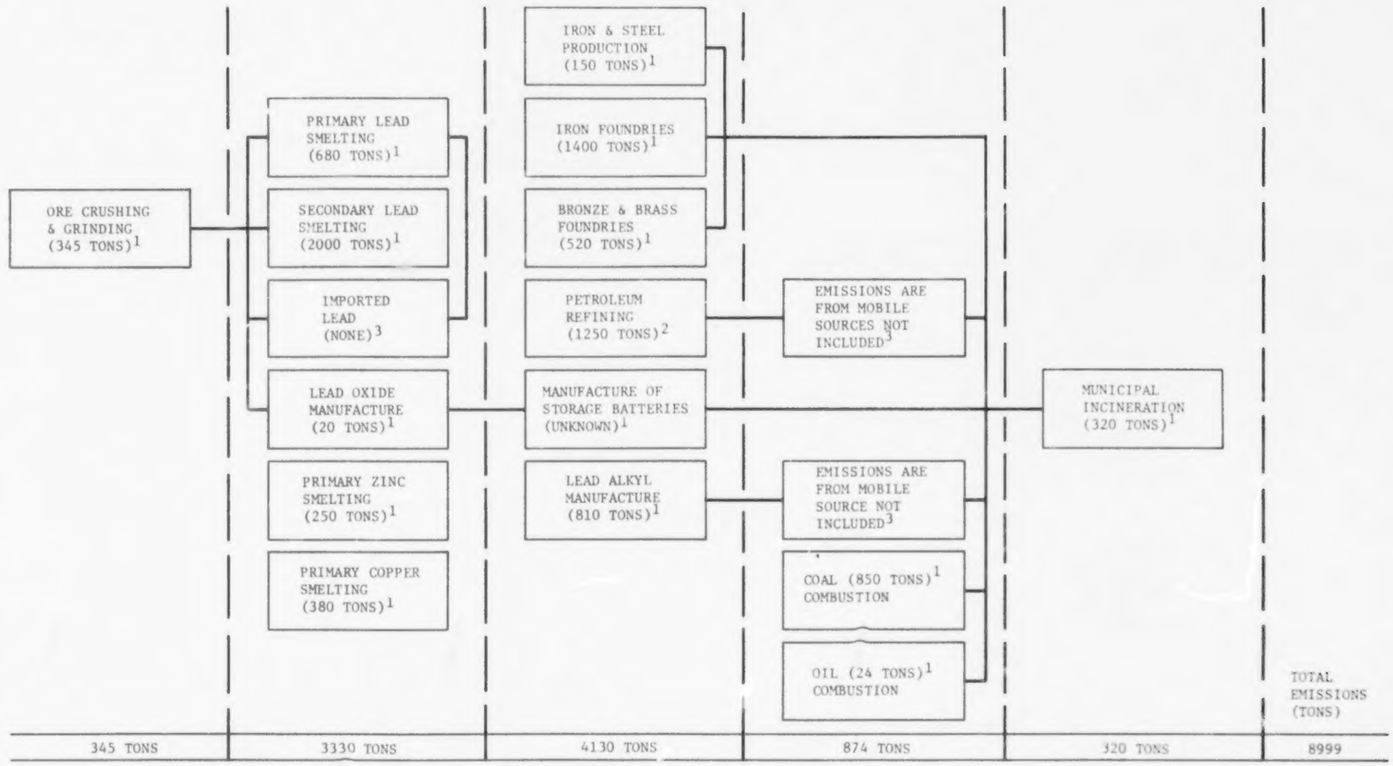

FLUORSPAR MINING (UNKNOWN)[1]
IMPORTED FLUORSPAR (NONE)[1]
PHOSPHATE ROCK MINING (UNKNOWN)[1]
HYDROFLUROIC[2] ACID PRODUCTION & ALKYLATION (6500 TONS)
MILLING & FLOTATION (UNKNOWN)[1]
Cu, Pb, Zn SMELTING & REFINING (1000 TONS)[2]
PROCESSING OF PHOSPHATE ROCK (21,300 TONS)[2]
IRON & STEEL PRODUCTION (64,600 TONS)[2]
PRIMARY ALUMINUM PRODUCTION (16,230 TONS)[2]
STRUCTURAL CLAY PRODUCTION (9720 TONS)[2]
EXPANDED CLAY AGGREGATE PRODUCTION (5300 TONS)[2]
OPAL GLASS PRODUCTION (3320 TONS)[2]
ENAMEL FRIT PRODUCTION (700 TONS)[2]
CEMENT MANUFACTURE (270 TONS)[2]
COAL (34,200 TONS) COMBUSTION[2]
INCINERATION (UNKNOWN)[3]
TOTAL EMISSIONS (TONS)
UNKNOWN
28,800 TONS
100,140 TONS
34,200 TONS
UNKNOWN
163,140

[1] MINERAL FACTS AND PROBLEMS, BOM.

[2] ENGINEERING AND COST EFFECTIVENESS STUDY OF FLUORIDE EMISSIONS CONTROL.

[3] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- FLUORIDES -

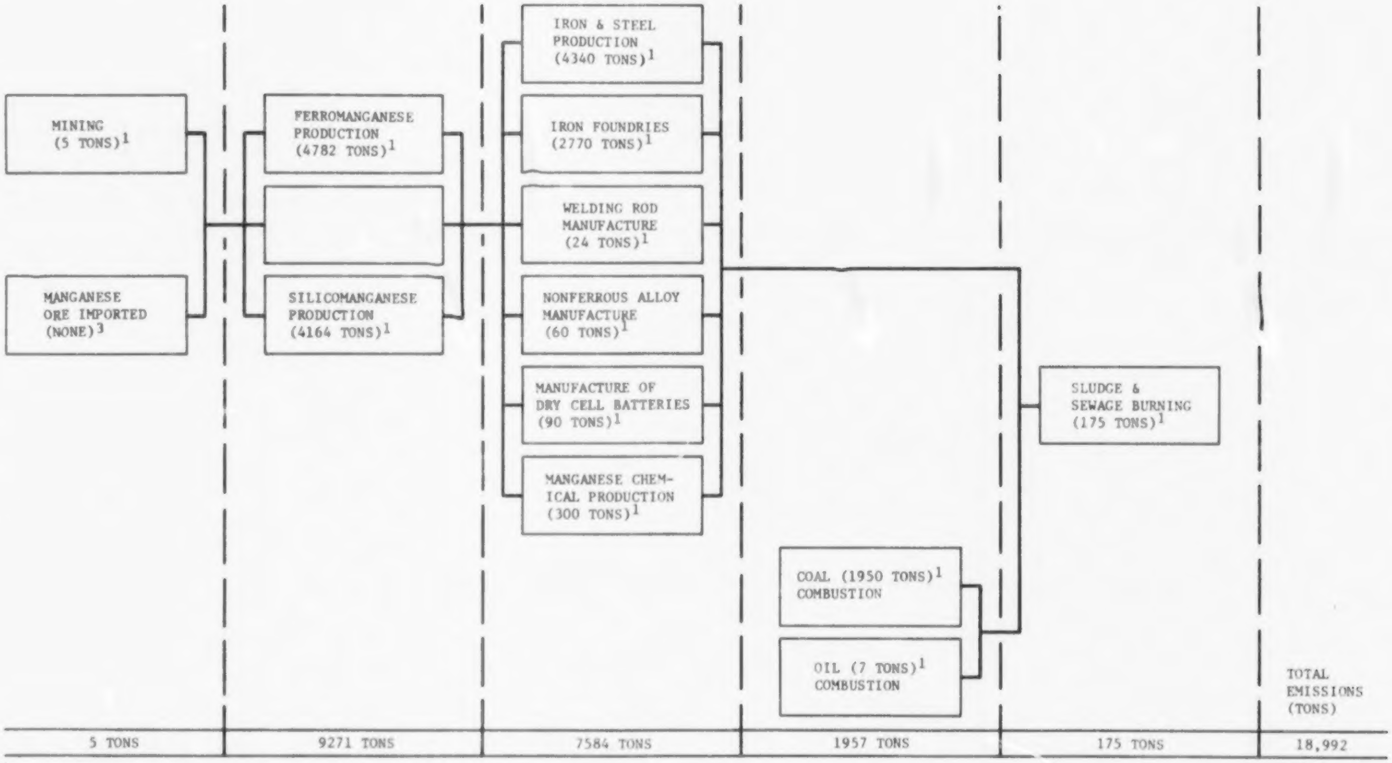

ORE CRUSHING & GRINDING (345 TONS)[1]
PRIMARY LEAD SMELTING (680 TONS)[1]
SECONDARY LEAD SMELTING (2000 TONS)[1]
IMPORTED LEAD (NONE)[3]
LEAD OXIDE MANUFACTURE (20 TONS)[1]
PRIMARY ZINC SMELTING (250 TONS)[1]
PRIMARY COPPER SMELTING (380 TONS)[1]
IRON & STEEL PRODUCTION (150 TONS)[1]
IRON FOUNDRIES (1400 TONS)[1]
BRONZE & BRASS FOUNDRIES (520 TONS)[1]
PETROLEUM REFINING (1250 TONS)[2]
MANUFACTURE OF STORAGE BATTERIES (UNKNOWN)[1]
LEAD ALKYL MANUFACTURE (810 TONS)[1]
EMISSIONS ARE FROM MOBILE SOURCES NOT INCLUDED[3]
EMISSIONS ARE FROM MOBILE SOURCE NOT INCLUDED[3]
COAL (850 TONS)[1] COMBUSTION
OIL (24 TONS)[1] COMBUSTION
MUNICIPAL INCINERATION (320 TONS)[1]
TOTAL EMISSIONS (TONS)
345 TONS
3330 TONS
4130 TONS
874 TONS
320 TONS
8999

[1] "CONTROL TECHNIQUES FOR LEAD EMISSIONS," EPA.

[2] MITRE

[3] MINERAL FACTS AND PROBLEMS, BOM.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- LEAD -

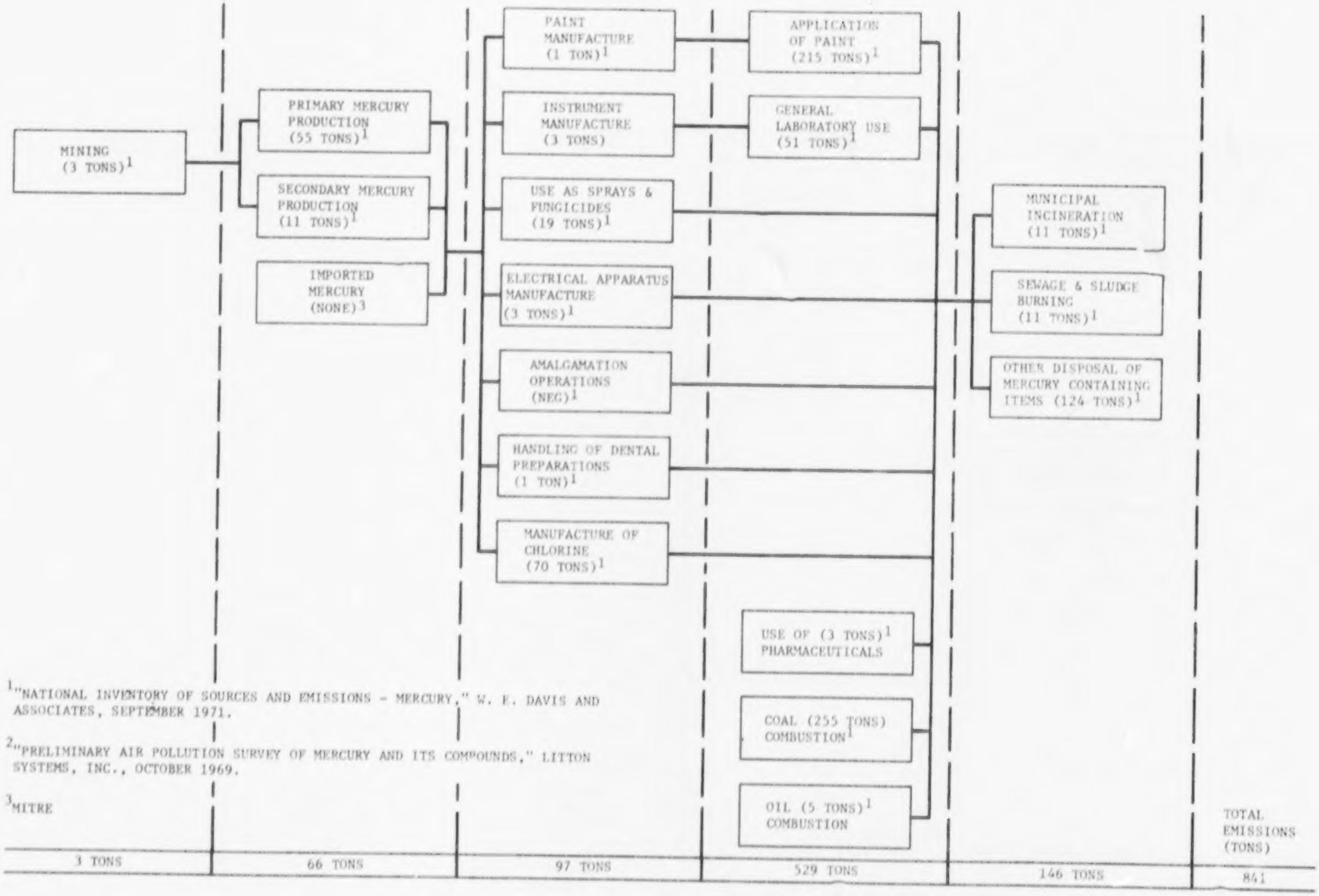

MINING (5 TONS)1
MANGANESE ORE IMPORTED (NONE)3
FERROMANGANESE PRODUCTION (4782 TONS)1
SILICOMANGANESE PRODUCTION (4164 TONS)1
IRON & STEEL PRODUCTION (4340 TONS)1
IRON FOUNDRIES (2770 TONS)1
WELDING ROD MANUFACTURE (24 TONS)1
NONFERROUS ALLOY MANUFACTURE (60 TONS)1
MANUFACTURE OF DRY CELL BATTERIES (90 TONS)1
MANGANESE CHEMICAL PRODUCTION (300 TONS)1
COAL (1950 TONS)1 COMBUSTION
OIL (7 TONS)1 COMBUSTION
SLUDGE & SEWAGE BURNING (175 TONS)1
TOTAL EMISSIONS (TONS)
5 TONS
9271 TONS
7584 TONS
1957 TONS
175 TONS
18,992

[1] W. E. DAVIS - "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - MANGANESE," W. E. DAVIS AND ASSOCIATES, AUGUST 1971.

[2] LITTON - "PRELIMINARY AIR POLLUTION SURVEY OF MANGANESE AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- MANGANESE -


MINING
(3 TONS)¹
PRIMARY MERCURY PRODUCTION (55 TONS)¹
SECONDARY MERCURY PRODUCTION (11 TONS)¹
IMPORTED MERCURY (NONE)³
PAINT MANUFACTURE (1 TON)¹
INSTRUMENT MANUFACTURE (3 TONS)
USE AS SPRAYS & FUNGICIDES (19 TONS)¹
ELECTRICAL APPARATUS MANUFACTURE (3 TONS)¹
AMALGAMATION OPERATIONS (NEG)¹
HANDLING OF DENTAL PREPARATIONS (1 TON)¹
MANUFACTURE OF CHLORINE (70 TONS)¹
APPLICATION OF PAINT (215 TONS)¹
GENERAL LABORATORY USE (51 TONS)¹
USE OF (3 TONS)¹ PHARMACEUTICALS
COAL (255 TONS) COMBUSTION¹
OIL (5 TONS)¹ COMBUSTION
MUNICIPAL INCINERATION (11 TONS)¹
SEWAGE & SLUDGE BURNING (11 TONS)¹
OTHER DISPOSAL OF MERCURY CONTAINING ITEMS (124 TONS)¹
TOTAL EMISSIONS (TONS)
3 TONS
66 TONS
97 TONS
529 TONS
146 TONS
841

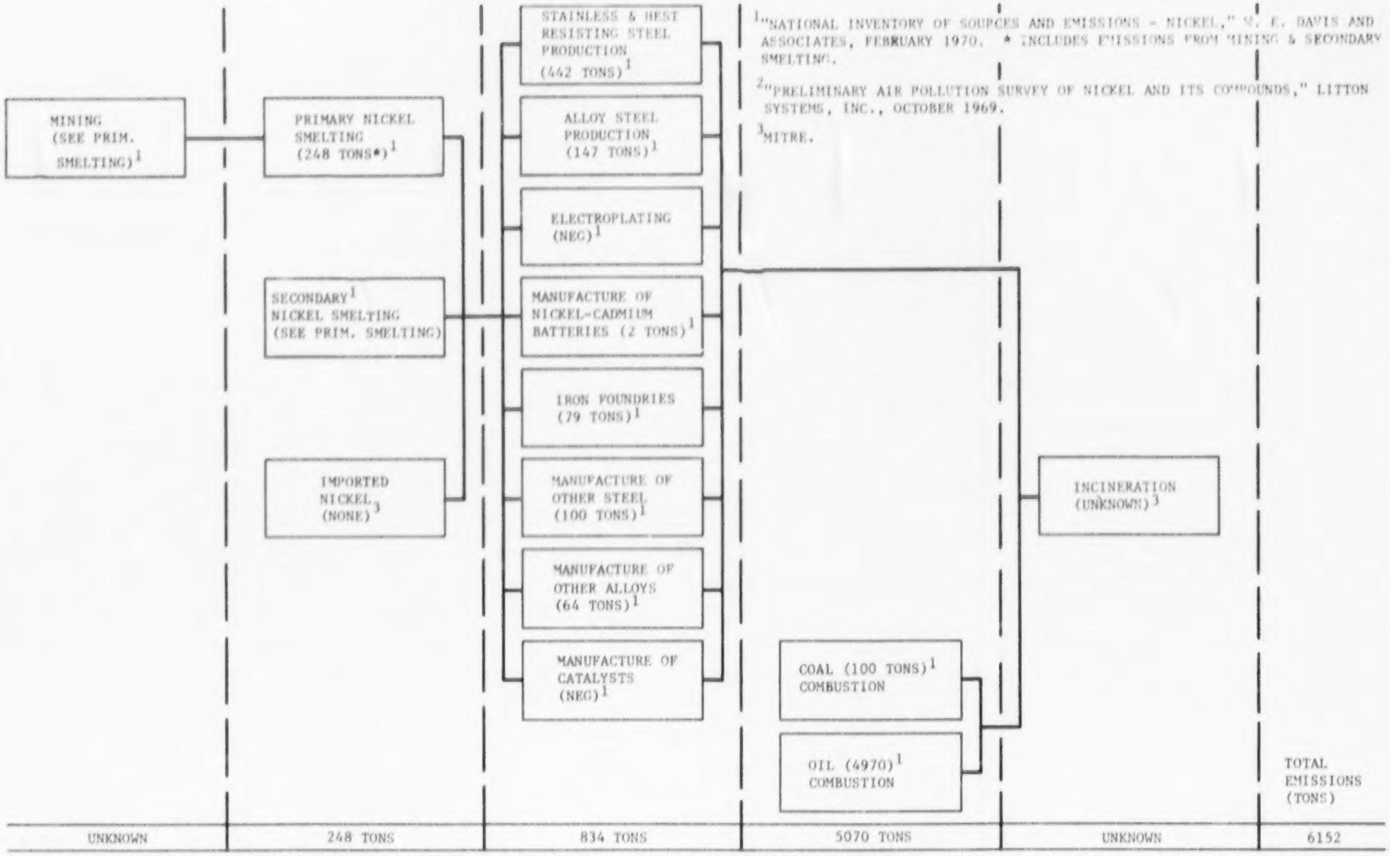
[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - MERCURY," W. E. DAVIS AND ASSOCIATES, SEPTEMBER 1971.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF MERCURY AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- MERCURY -

]

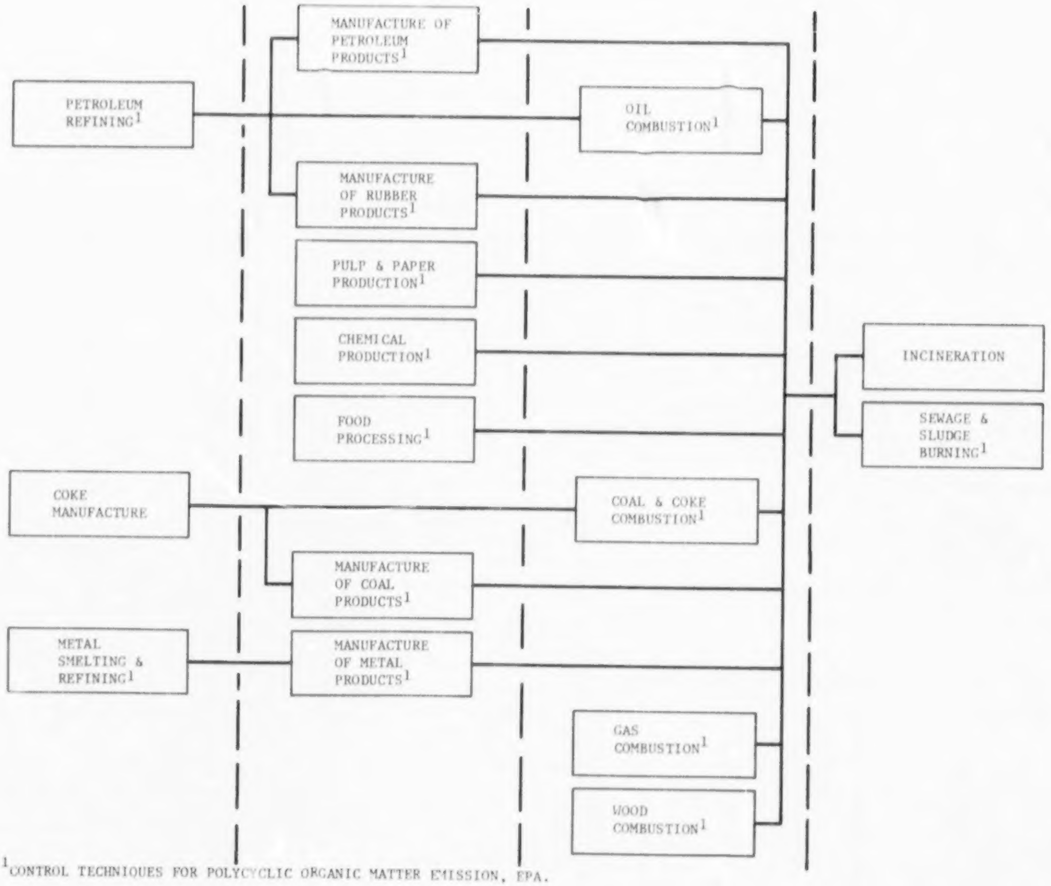

MINING (SEE PRIM. SMELTING)[1]
PRIMARY NICKEL SMELTING (248 TONS*)[1]
SECONDARY[1] NICKEL SMELTING (SEE PRIM. SMELTING)
IMPORTED NICKEL (NONE)[3]
STAINLESS & HEST RESISTING STEEL PRODUCTION (442 TONS)[1]
ALLOY STEEL PRODUCTION (147 TONS)[1]
ELECTROPLATING (NEG)[1]
MANUFACTURE OF NICKEL-CADMIUM BATTERIES (2 TONS)[1]
IRON FOUNDRIES (79 TONS)[1]
MANUFACTURE OF OTHER STEEL (100 TONS)[1]
MANUFACTURE OF OTHER ALLOYS (64 TONS)[1]
MANUFACTURE OF CATALYSTS (NEG)[1]
COAL (100 TONS)[1] COMBUSTION
OIL (4970)[1] COMBUSTION
INCINERATION (UNKNOWN)[3]
TOTAL EMISSIONS (TONS)
UNKNOWN
248 TONS
834 TONS
5070 TONS
UNKNOWN
6152

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- NICKEL -

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - NICKEL," W. E. DAVIS AND ASSOCIATES, FEBRUARY 1970. * INCLUDES EMISSIONS FROM MINING & SECONDARY SMELTING.

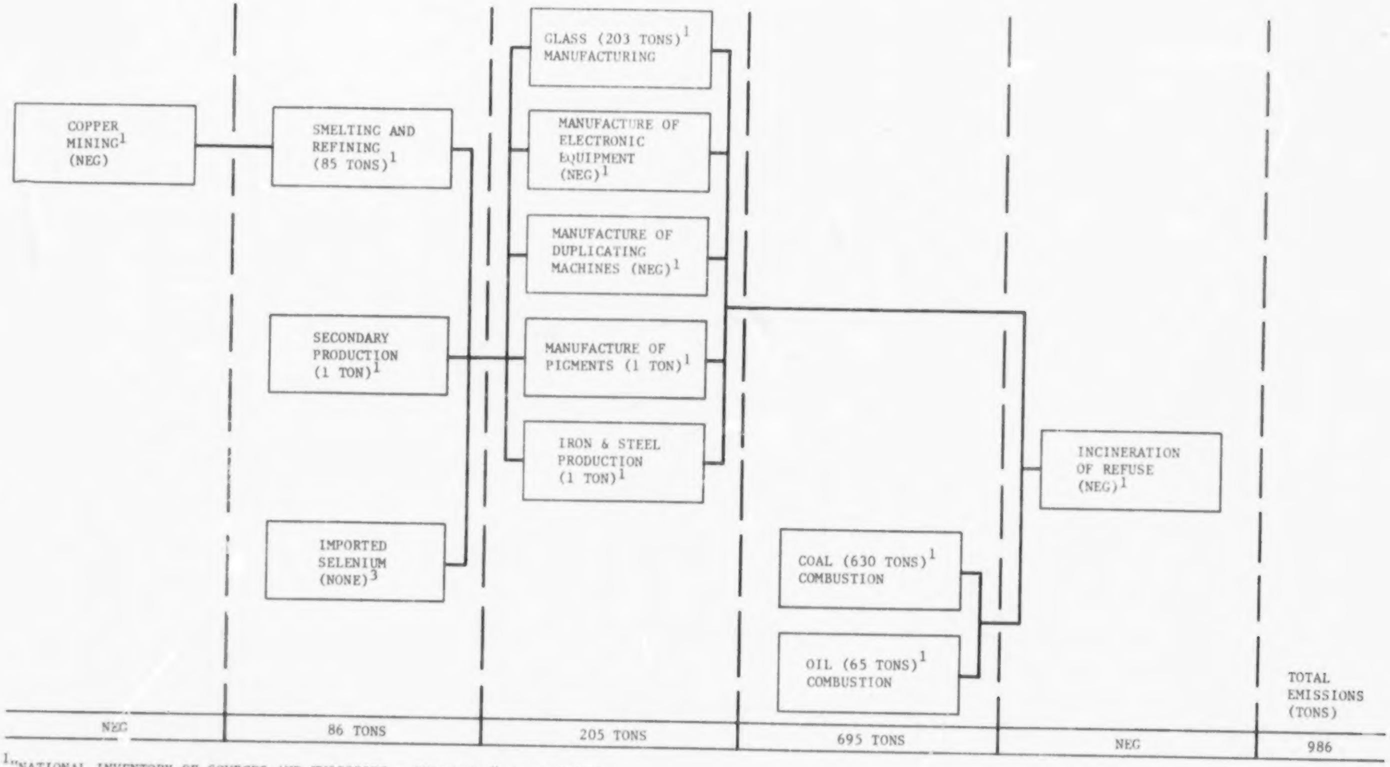
[2] "PRELIMINARY AIR POLLUTION SURVEY OF NICKEL AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE.


PETROLEUM REFINING1
COKE MANUFACTURE
METAL SMELTING & REFINING1
MANUFACTURE OF PETROLEUM PRODUCTS1
MANUFACTURE OF RUBBER PRODUCTS1
PULP & PAPER PRODUCTION1
CHEMICAL PRODUCTION1
FOOD PROCESSING1
MANUFACTURE OF COAL PRODUCTS1
MANUFACTURE OF METAL PRODUCTS1
OIL COMBUSTION1
COAL & COKE COMBUSTION1
GAS COMBUSTION1
WOOD COMBUSTION1
INCINERATION
SEWAGE & SLUDGE BURNING1

[1] CONTROL TECHNIQUES FOR POLYCYCLIC ORGANIC MATTER EMISSION, EPA.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- POM -


COPPER MINING[1] (NEG)
SMELTING AND REFINING (85 TONS)[1]
SECONDARY PRODUCTION (1 TON)[1]
IMPORTED SELENIUM (NONE)[3]
GLASS (203 TONS)[1] MANUFACTURING
MANUFACTURE OF ELECTRONIC EQUIPMENT (NEG)[1]
MANUFACTURE OF DUPLICATING MACHINES (NEG)[1]
MANUFACTURE OF PIGMENTS (1 TON)[1]
IRON & STEEL PRODUCTION (1 TON)[1]
COAL (630 TONS)[1] COMBUSTION
OIL (65 TONS)[1] COMBUSTION
INCINERATION OF REFUSE (NEG)[1]
TOTAL EMISSIONS (TONS)
NEG
86 TONS
205 TONS
695 TONS
NEG
986

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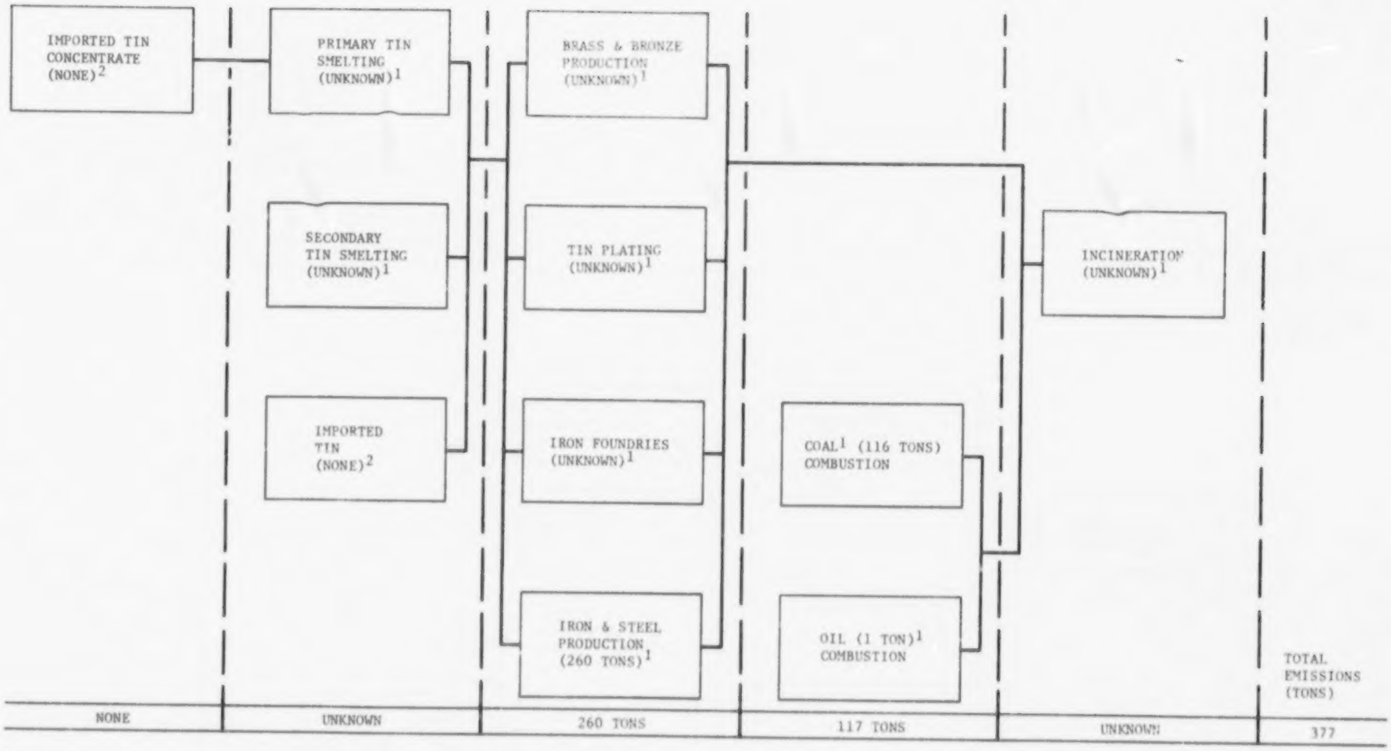
[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - SELENIUM," W. E. DAVIS AND ASSOCIATES, APRIL 1972.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF SELENIUM AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE.

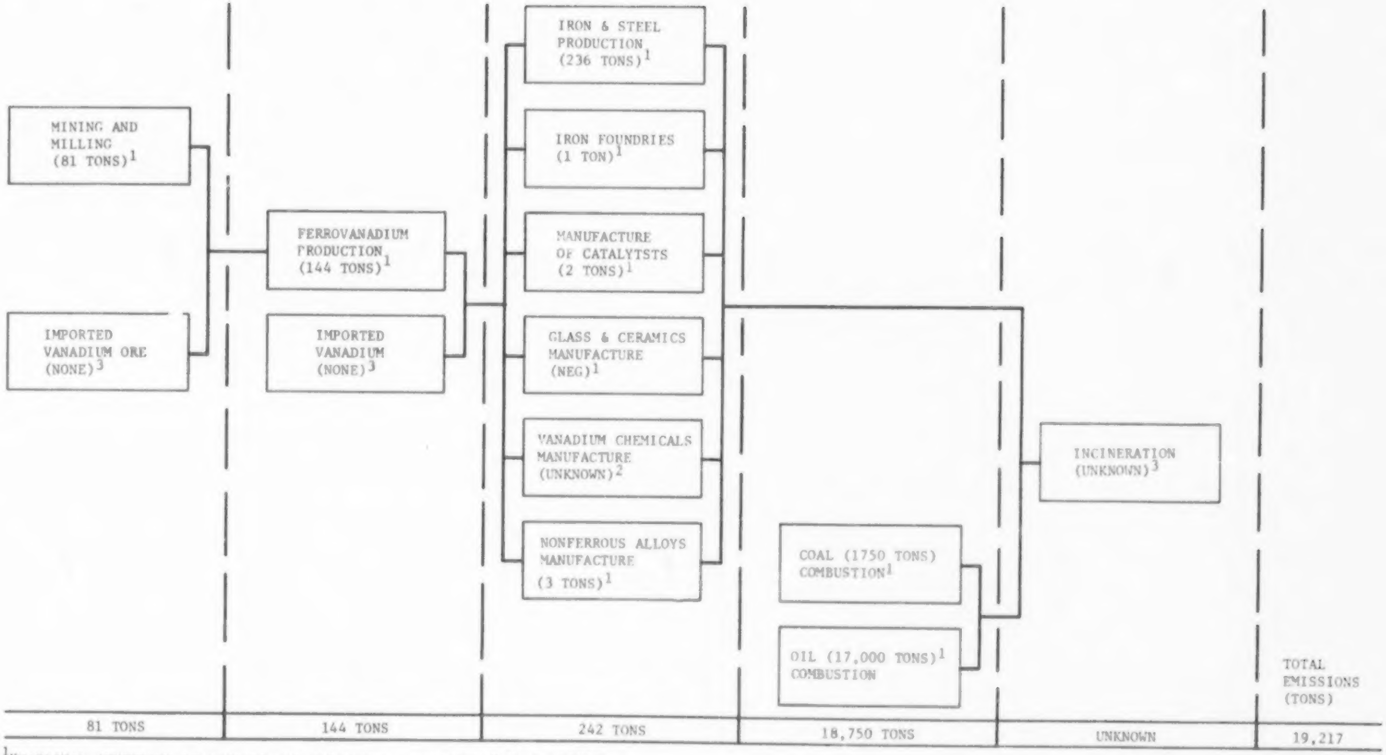
MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- SELENIUM -


IMPORTED TIN CONCENTRATE (NONE)2
PRIMARY TIN SMELTING (UNKNOWN)1
SECONDARY TIN SMELTING (UNKNOWN)1
IMPORTED TIN (NONE)2
BRASS & BRONZE PRODUCTION (UNKNOWN)1
TIN PLATING (UNKNOWN)1
IRON FOUNDRIES (UNKNOWN)1
IRON & STEEL PRODUCTION (260 TONS)1
COAL1 (116 TONS) COMBUSTION
OIL (1 TON)1 COMBUSTION
INCINERATION (UNKNOWN)1
TOTAL EMISSIONS (TONS)
NONE
UNKNOWN
260 TONS
117 TONS
UNKNOWN
377

[1] MITRE

[2] MINERAL FACTS AND PROBLEMS, BOM

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
TIN

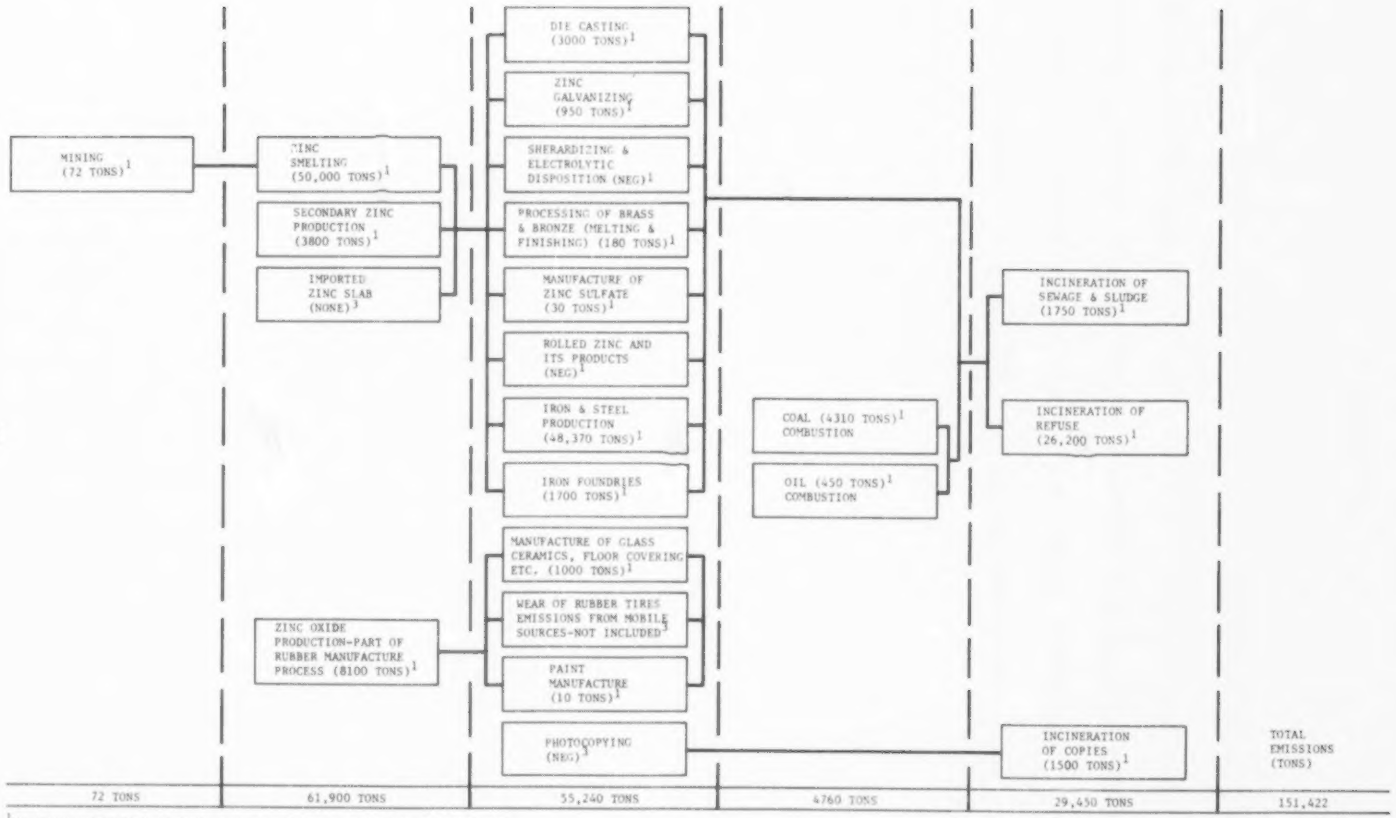

MINING AND MILLING (81 TONS)[1]
IMPORTED VANADIUM ORE (NONE)[3]
FERROVANADIUM PRODUCTION (144 TONS)[1]
IMPORTED VANADIUM (NONE)[3]
IRON & STEEL PRODUCTION (236 TONS)[1]
IRON FOUNDRIES (1 TON)[1]
MANUFACTURE OF CATALYTSTS (2 TONS)[1]
GLASS & CERAMICS MANUFACTURE (NEG)[1]
VANADIUM CHEMICALS MANUFACTURE (UNKNOWN)[2]
NONFERROUS ALLOYS MANUFACTURE (3 TONS)[1]
COAL (1750 TONS) COMBUSTION[1]
OIL (17,000 TONS)[1] COMBUSTION
INCINERATION (UNKNOWN)[3]
TOTAL EMISSIONS (TONS)
81 TONS
144 TONS
242 TONS
18,750 TONS
UNKNOWN
19,217

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - VANADIUM," W. E. DAVIS AND ASSOCIATES, JUNE 1971.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF VANADIUM AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

[3] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- VANADIUM -


MINING (72 TONS)1
ZINC SMELTING (50,000 TONS)1
SECONDARY ZINC PRODUCTION (3800 TONS)1
IMPORTED ZINC SLAB (NONE)3
ZINC OXIDE PRODUCTION-PART OF RUBBER MANUFACTURE PROCESS (8100 TONS)1
DIE CASTING (3000 TONS)1
ZINC GALVANIZING (950 TONS)1
SHERARDIZING & ELECTROLYTIC DISPOSITION (NEG)1
PROCESSING OF BRASS & BRONZE (MELTING & FINISHING) (180 TONS)1
MANUFACTURE OF ZINC SULFATE (30 TONS)1
ROLLED ZINC AND ITS PRODUCTS (NEG)1
IRON & STEEL PRODUCTION (48,370 TONS)1
IRON FOUNDRIES (1700 TONS)1
MANUFACTURE OF GLASS CERAMICS, FLOOR COVERING ETC. (1000 TONS)1
WEAR OF RUBBER TIRES EMISSIONS FROM MOBILE SOURCES-NOT INCLUDED3
PAINT MANUFACTURE (10 TONS)1
PHOTOCOPYING (NEG)3
COAL (4310 TONS)1 COMBUSTION
OIL (450 TONS)1 COMBUSTION
INCINERATION OF SEWAGE & SLUDGE (1750 TONS)1
INCINERATION OF REFUSE (26,200 TONS)1
INCINERATION OF COPIES (1500 TONS)1
TOTAL EMISSIONS (TONS)
72 TONS
61,900 TONS
55,240 TONS
4760 TONS
29,450 TONS
151,422

[1] "NATIONAL INVENTORY OF SOURCES AND EMISSIONS - ZINC," W. E. DAVIS AND ASSOCIATES, MAY 1972.

[2] "PRELIMINARY AIR POLLUTION SURVEY OF ZINC AND ITS COMPOUNDS," LITTON SYSTEMS, INC., OCTOBER 1969.

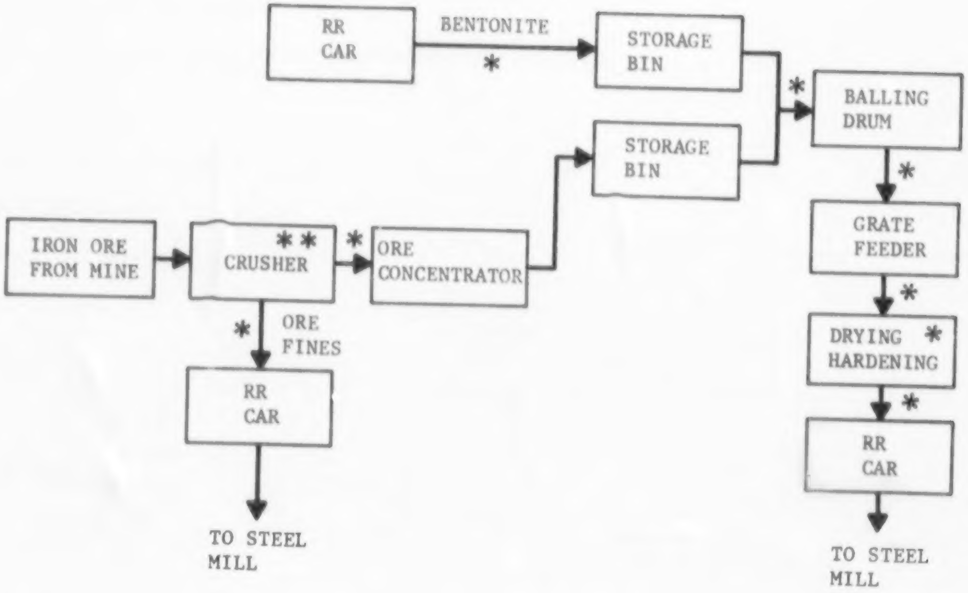
[3] MITRE.

MATERIAL FLOW THROUGH THE ECONOMY SHOWING PRIMARY EMISSION SOURCES
- ZINC -

# APPENDIX D

## PROCESS FLOW CHARTS

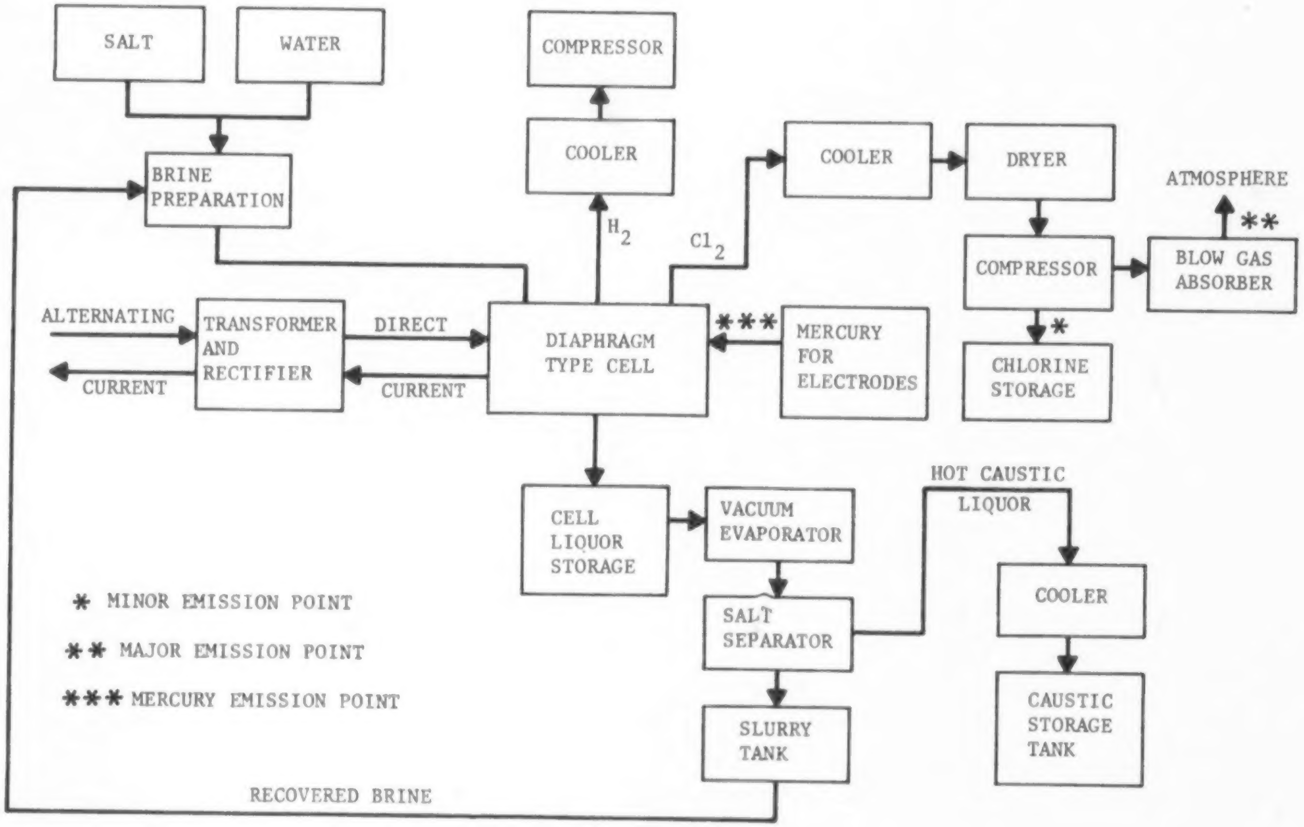
In this section are collected a series of flow charts prepared by The MITRE Corporation for each of the largest emitting processes which were identified during the course of the study. On each chart the major and minor points of emission are identified.


RR CAR
BENTONITE
*
STORAGE BIN
STORAGE BIN
*
BALLING DRUM
*
GRATE FEEDER
*
DRYING HARDENING
*
*
RR CAR
TO STEEL MILL
IRON ORE FROM MINE
CRUSHER
**
*
ORE CONCENTRATOR
*
ORE FINES
RR CAR
TO STEEL MILL

* MINOR EMISSION POINT
** MAJOR EMISSION POINT

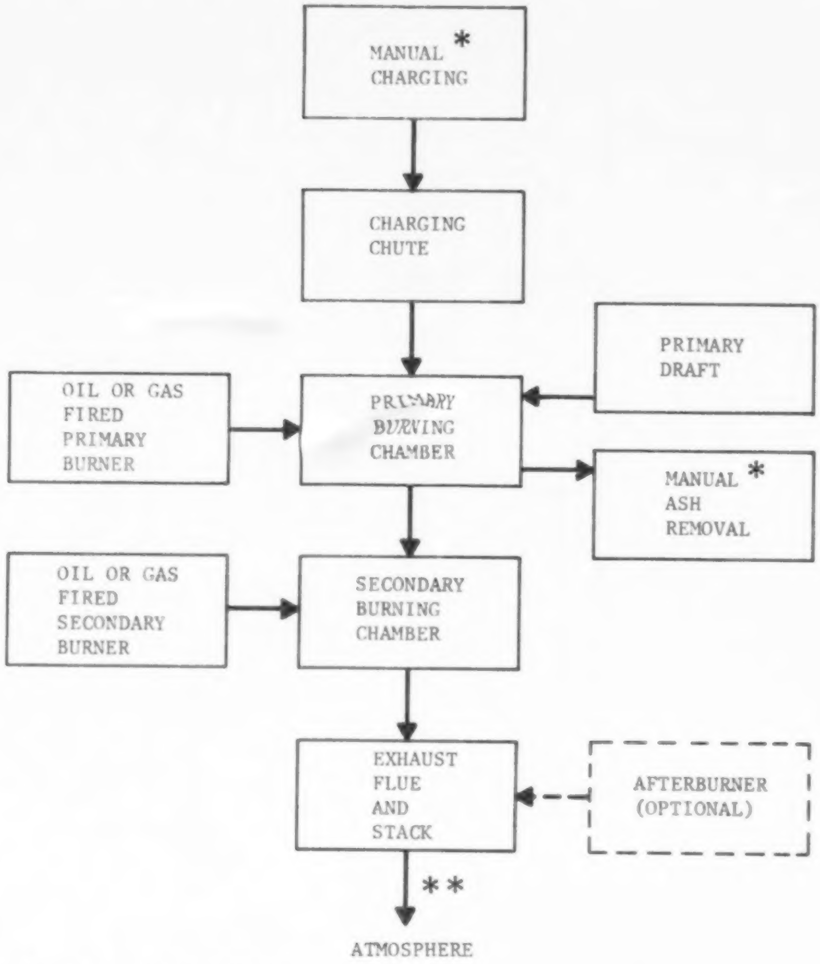
SOURCE: MRI

BASIC OPERATIONS - IRON ORE PELLET PLANT


SALT
WATER
BRINE PREPARATION
COMPRESSOR
COOLER
$H_2$
$Cl_2$
COOLER
DRYER
ATMOSPHERE
**
COMPRESSOR
BLOW GAS ABSORBER
*
CHLORINE STORAGE
ALTERNATING
CURRENT
TRANSFORMER AND RECTIFIER
DIRECT
CURRENT
DIAPHRAGM TYPE CELL
***
MERCURY FOR ELECTRODES
CELL LIQUOR STORAGE
VACUUM EVAPORATOR
SALT SEPARATOR
SLURRY TANK
HOT CAUSTIC LIQUOR
COOLER
CAUSTIC STORAGE TANK
RECOVERED BRINE
* MINOR EMISSION POINT
** MAJOR EMISSION POINT
*** MERCURY EMISSION POINT

SOURCE: ENGINEERING SCIENCE, INC.

IC OPERATIONS - DIAPHRAGM CELL CHLOR-ALKALI

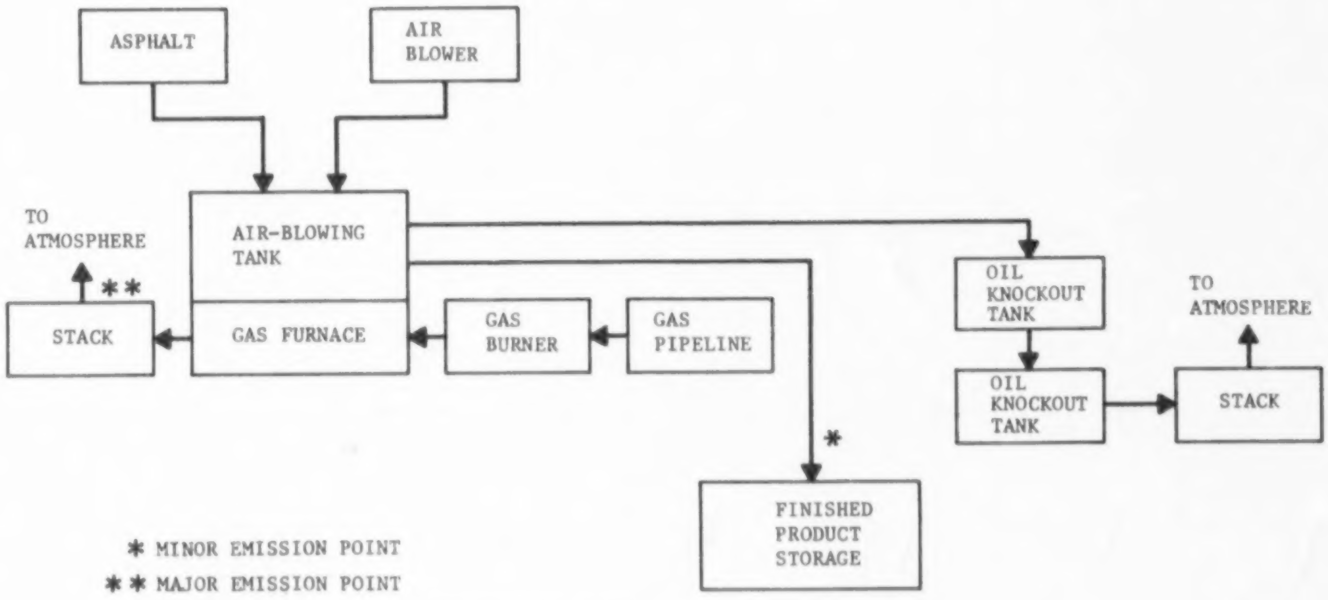

MANUAL *
CHARGING
CHARGING
CHUTE
PRIMARY
DRAFT
OIL OR GAS
FIRED
PRIMARY
BURNER
PRIMARY
BURNING
CHAMBER
MANUAL *
ASH
REMOVAL
OIL OR GAS
FIRED
SECONDARY
BURNER
SECONDARY
BURNING
CHAMBER
EXHAUST
FLUE
AND
STACK
AFTERBURNER
(OPTIONAL)
**
ATMOSPHERE

* MINOR EMISSION POINT

** MAJOR EMISSION POINT

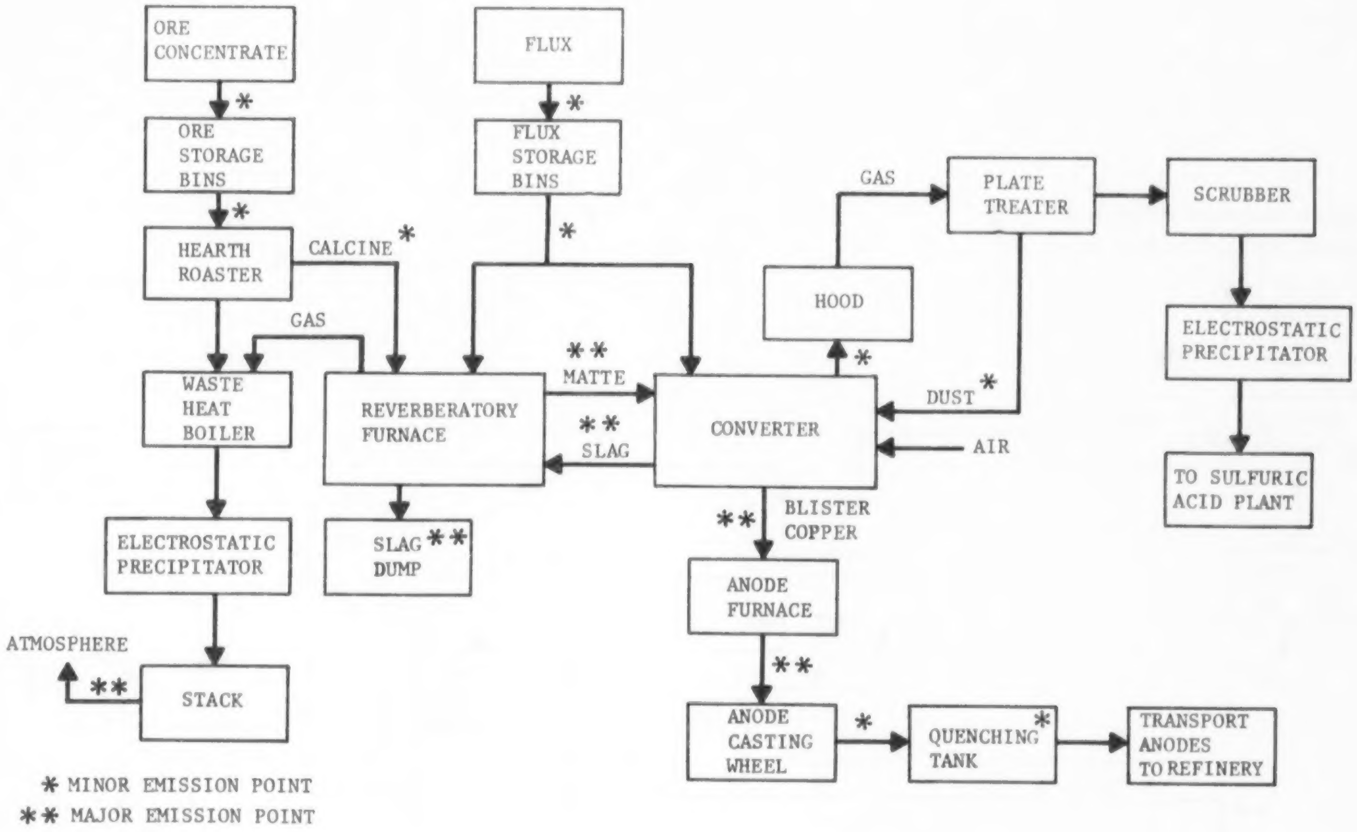
SOURCE: AIR POLLUTION ENGINEERING MANUAL

BASIC OPERATIONS - TYPICAL APARTMENT HOUSE TYPE INCINERATOR


ASPHALT
AIR BLOWER
TO ATMOSPHERE
**
STACK
AIR-BLOWING TANK
GAS FURNACE
GAS BURNER
GAS PIPELINE
*
FINISHED PRODUCT STORAGE
OIL KNOCKOUT TANK
OIL KNOCKOUT TANK
TO ATMOSPHERE
STACK
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

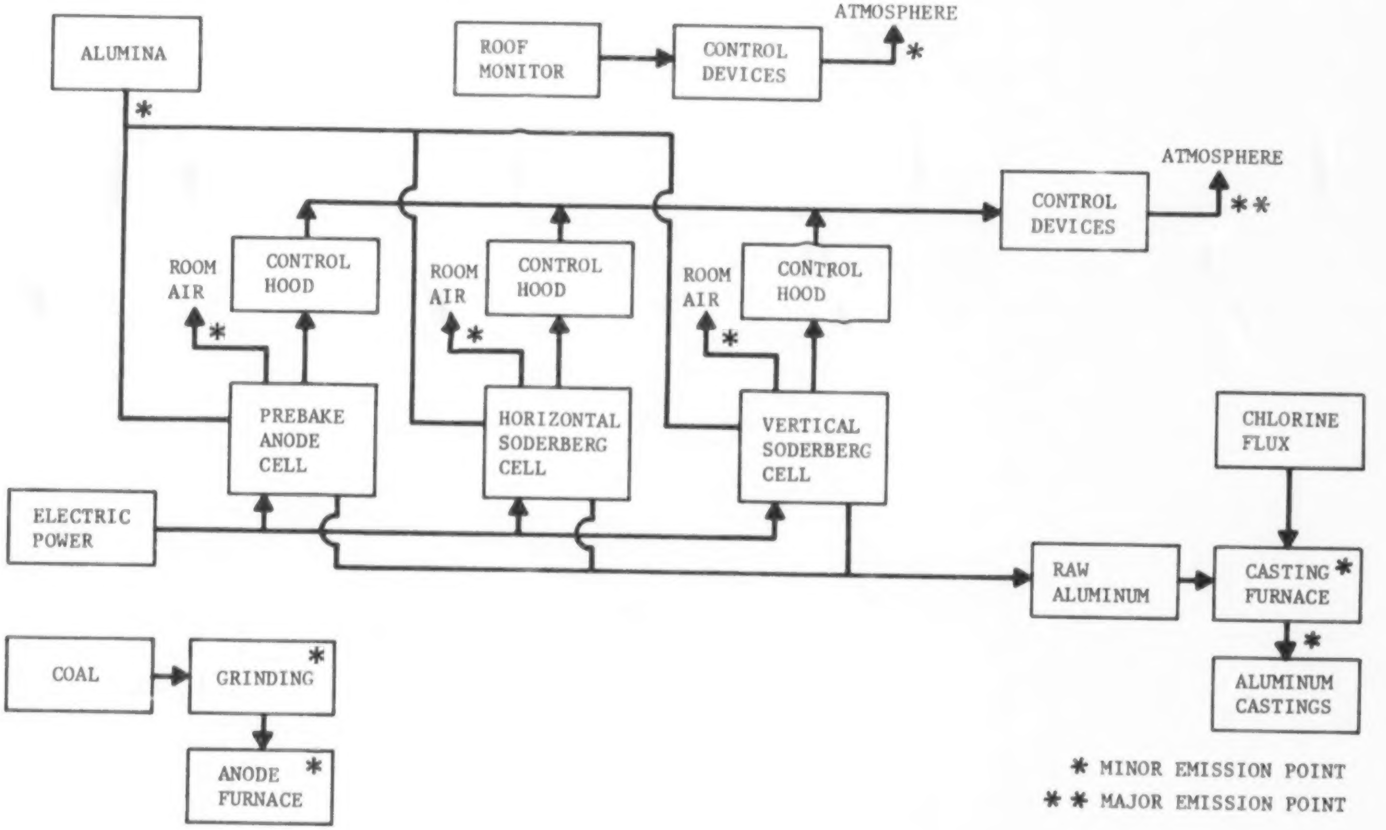
SOURCE: AIR POLLUTION ENGINEERING MANUAL

BA OPERATIONS - TYPICAL ASPHALT AIR-BLOWING PROCESS


ORE CONCENTRATE
*
ORE STORAGE BINS
*
HEARTH ROASTER
CALCINE *
GAS
WASTE HEAT BOILER
ELECTROSTATIC PRECIPITATOR
STACK
**
ATMOSPHERE
FLUX
*
FLUX STORAGE BINS
*
REVERBERATORY FURNACE
SLAG DUMP **
** MATTE
** SLAG
CONVERTER
*
HOOD
GAS
PLATE TREATER
SCRUBBER
ELECTROSTATIC PRECIPITATOR
TO SULFURIC ACID PLANT
DUST *
AIR
** BLISTER COPPER
ANODE FURNACE
**
ANODE CASTING WHEEL
*
QUENCHING TANK *
TRANSPORT ANODES TO REFINERY
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

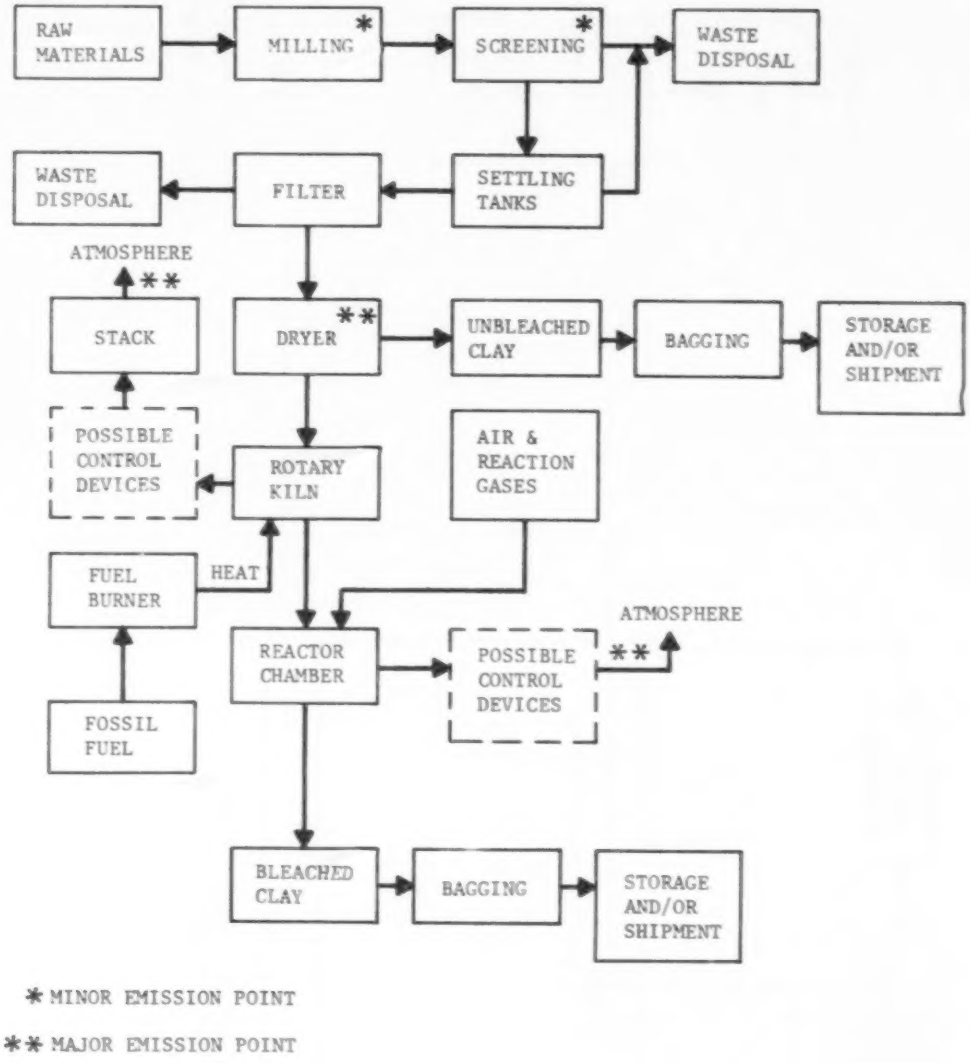
SOURCE: MRI

BASIC OPERATIONS - PRIMARY COPPER SMELTING


ALUMINA
ROOF MONITOR
CONTROL DEVICES
ATMOSPHERE
CONTROL DEVICES
ATMOSPHERE
ROOM AIR
CONTROL HOOD
ROOM AIR
CONTROL HOOD
ROOM AIR
CONTROL HOOD
PREBAKE ANODE CELL
HORIZONTAL SODERBERG CELL
VERTICAL SODERBERG CELL
CHLORINE FLUX
ELECTRIC POWER
RAW ALUMINUM
CASTING FURNACE
ALUMINUM CASTINGS
COAL
GRINDING
ANODE FURNACE
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

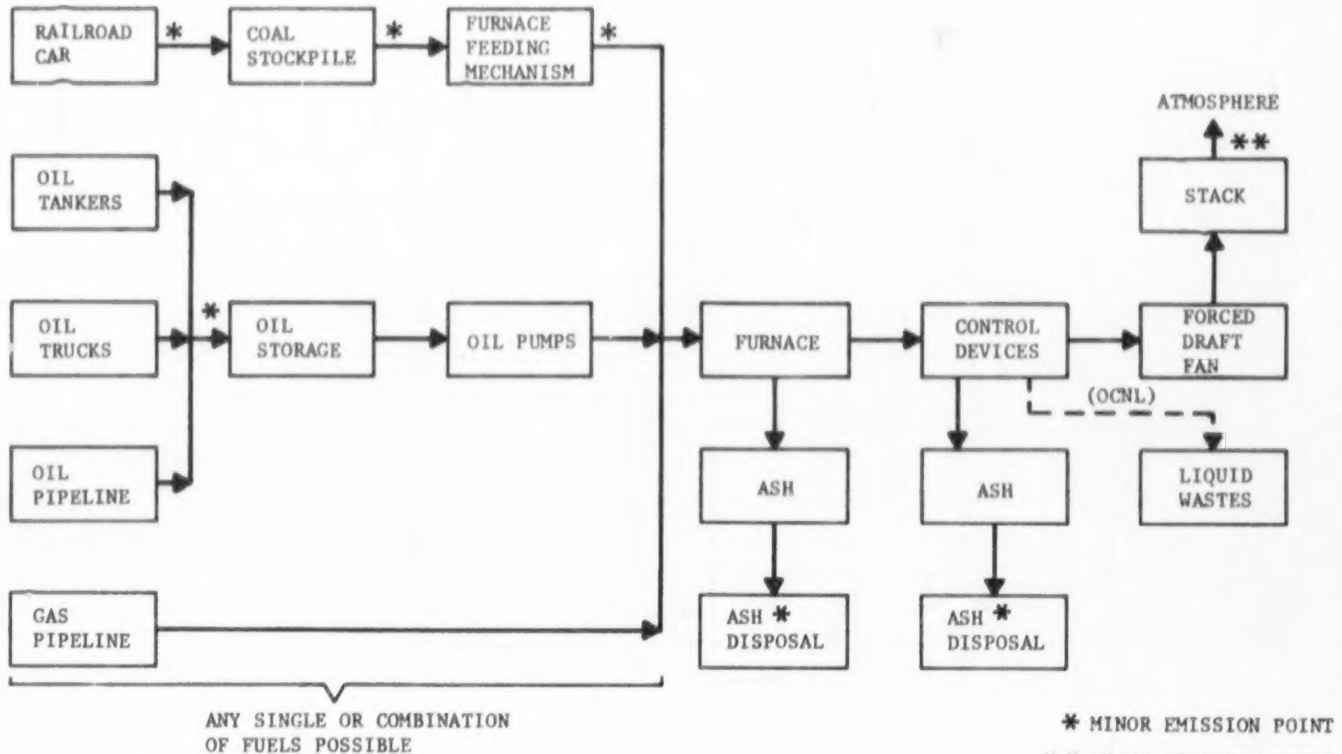
SOURCE: MITRE

BASIC OPERATIONS - PRIMARY ALUMINUM


RAW MATERIALS
MILLING *
SCREENING *
WASTE DISPOSAL
WASTE DISPOSAL
FILTER
SETTLING TANKS
ATMOSPHERE
**
STACK
DRYER **
UNBLEACHED CLAY
BAGGING
STORAGE AND/OR SHIPMENT
POSSIBLE CONTROL DEVICES
ROTARY KILN
AIR & REACTION GASES
FUEL BURNER
HEAT
ATMOSPHERE
REACTOR CHAMBER
POSSIBLE CONTROL DEVICES
**
FOSSIL FUEL
BLEACHED CLAY
BAGGING
STORAGE AND/OR SHIPMENT
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

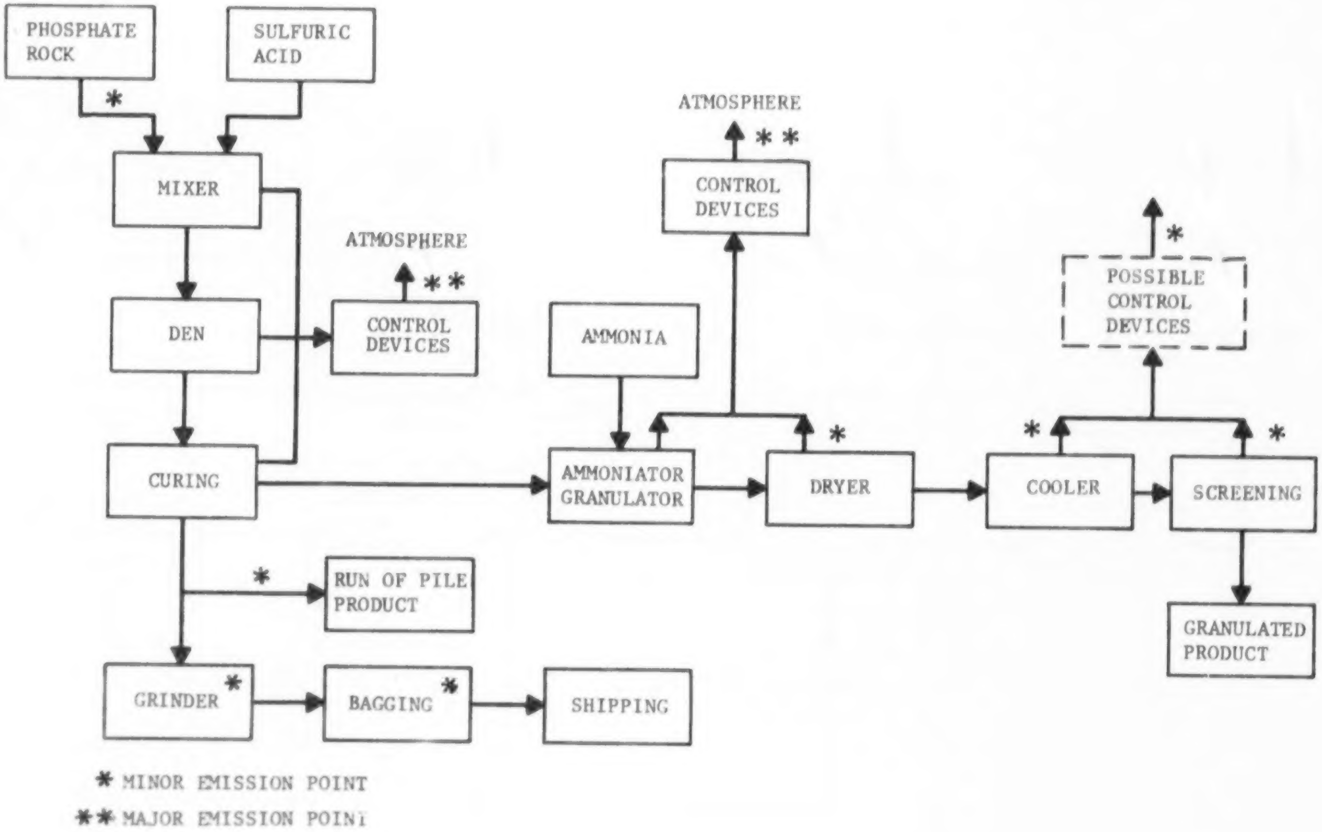
SOURCE: MRI

BASIC OPERATIONS - RAW CERAMIC CLAY MANUFACTURE


RAILROAD CAR
*
COAL STOCKPILE
*
FURNACE FEEDING MECHANISM
*
OIL TANKERS
OIL TRUCKS
OIL PIPELINE
*
OIL STORAGE
OIL PUMPS
GAS PIPELINE
ANY SINGLE OR COMBINATION OF FUELS POSSIBLE
FURNACE
ASH
ASH * DISPOSAL
CONTROL DEVICES
ASH
ASH * DISPOSAL
(OCNL)
LIQUID WASTES
FORCED DRAFT FAN
STACK
**
ATMOSPHERE
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

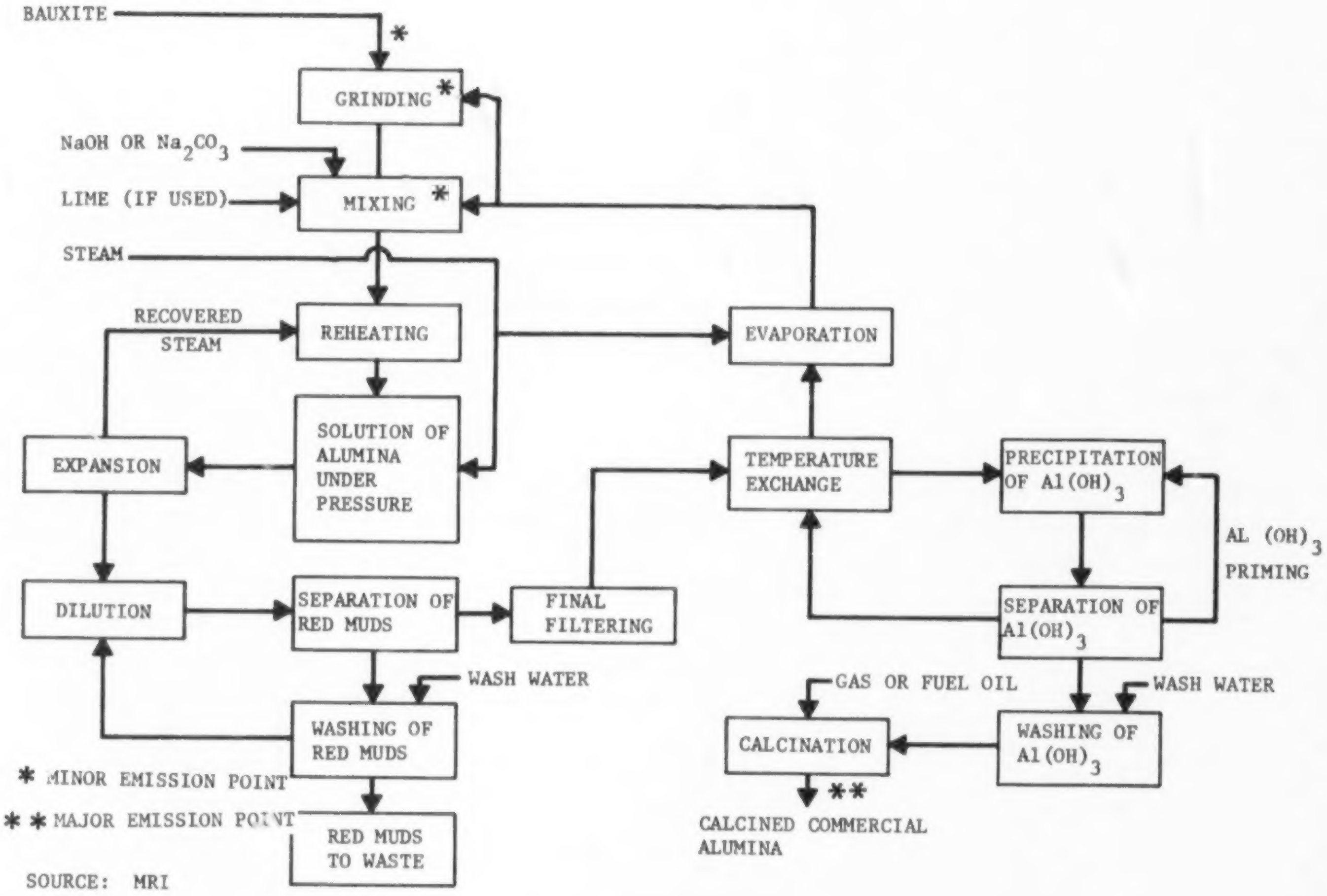
SOURCE: MITRE

SIC OPERATIONS - POWER PLANT COMBUSTION


PHOSPHATE ROCK
SULFURIC ACID
MIXER
DEN
CURING
CONTROL DEVICES
ATMOSPHERE
AMMONIA
AMMONIATOR GRANULATOR
CONTROL DEVICES
ATMOSPHERE
DRYER
COOLER
SCREENING
POSSIBLE CONTROL DEVICES
GRANULATED PRODUCT
RUN OF PILE PRODUCT
GRINDER
BAGGING
SHIPPING
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

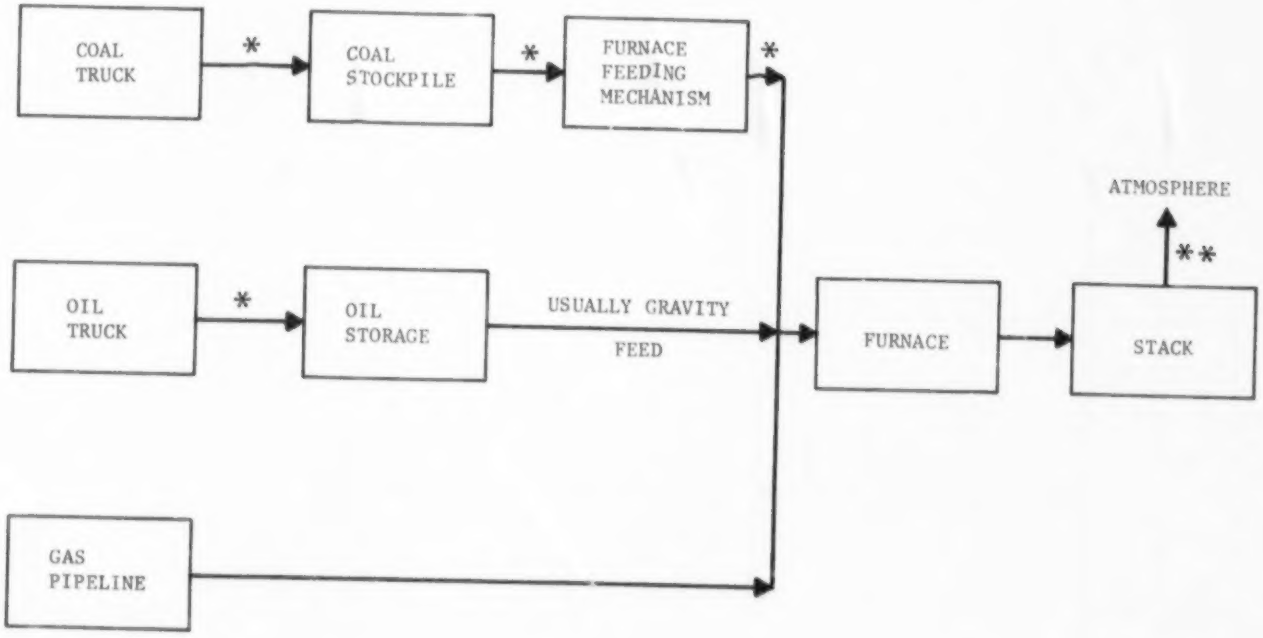
SOURCE: MRI

BASIC OPERATIONS - NORMAL SUPERPHOSPHATE MANUFACTURE


BAUXITE
GRINDING *
NaOH OR $Na_2CO_3$
LIME (IF USED)
MIXING *
STEAM
RECOVERED STEAM
REHEATING
SOLUTION OF ALUMINA UNDER PRESSURE
EXPANSION
DILUTION
SEPARATION OF RED MUDS
FINAL FILTERING
WASH WATER
WASHING OF RED MUDS
RED MUDS TO WASTE
EVAPORATION
TEMPERATURE EXCHANGE
PRECIPITATION OF $Al(OH)_3$
AL $(OH)_3$ PRIMING
SEPARATION OF $Al(OH)_3$
WASH WATER
WASHING OF $Al(OH)_3$
GAS OR FUEL OIL
CALCINATION
**
CALCINED COMMERCIAL ALUMINA
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

SOURCE: MRI

BASIC OPERATIONS - MANUFACTURE OF ALUMINA

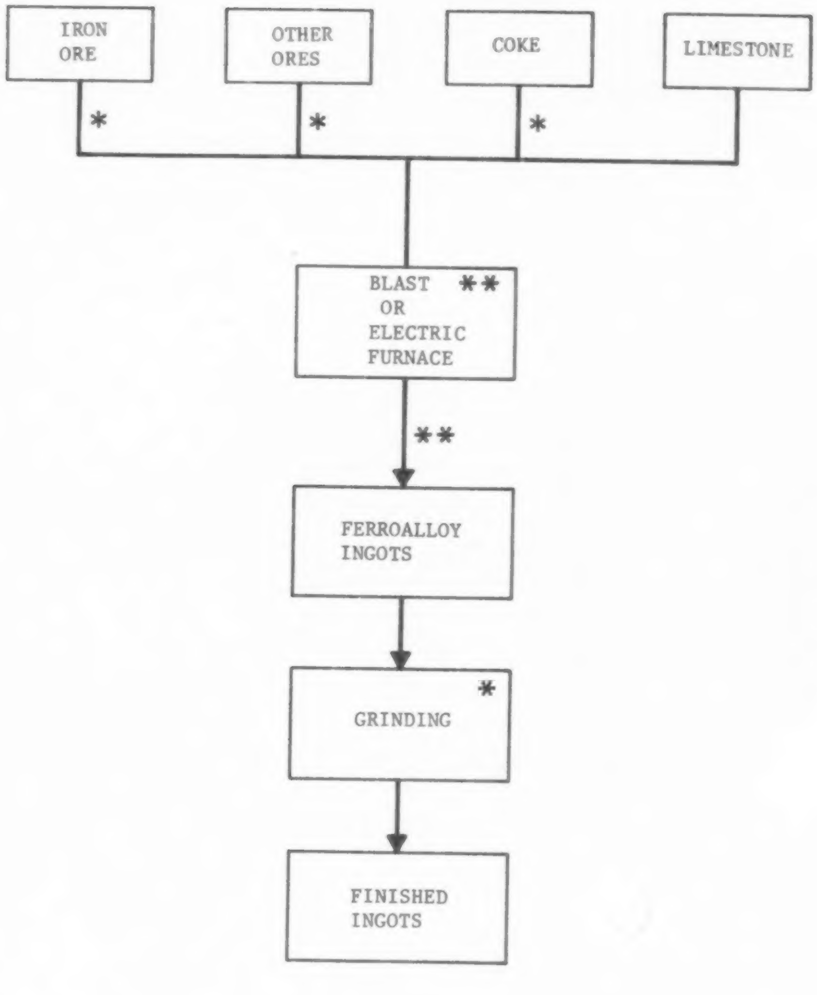

COAL TRUCK
*
COAL STOCKPILE
*
FURNACE FEEDING MECHANISM
*
OIL TRUCK
*
OIL STORAGE
USUALLY GRAVITY FEED
GAS PIPELINE
FURNACE
STACK
**
ATMOSPHERE

* MINOR EMISSION POINT

** MAJOR EMISSION POINT

SOURCE: MITRE

BASIC OPERATIONS - COMMERCIAL/RESIDENTIAL COMBUSTION

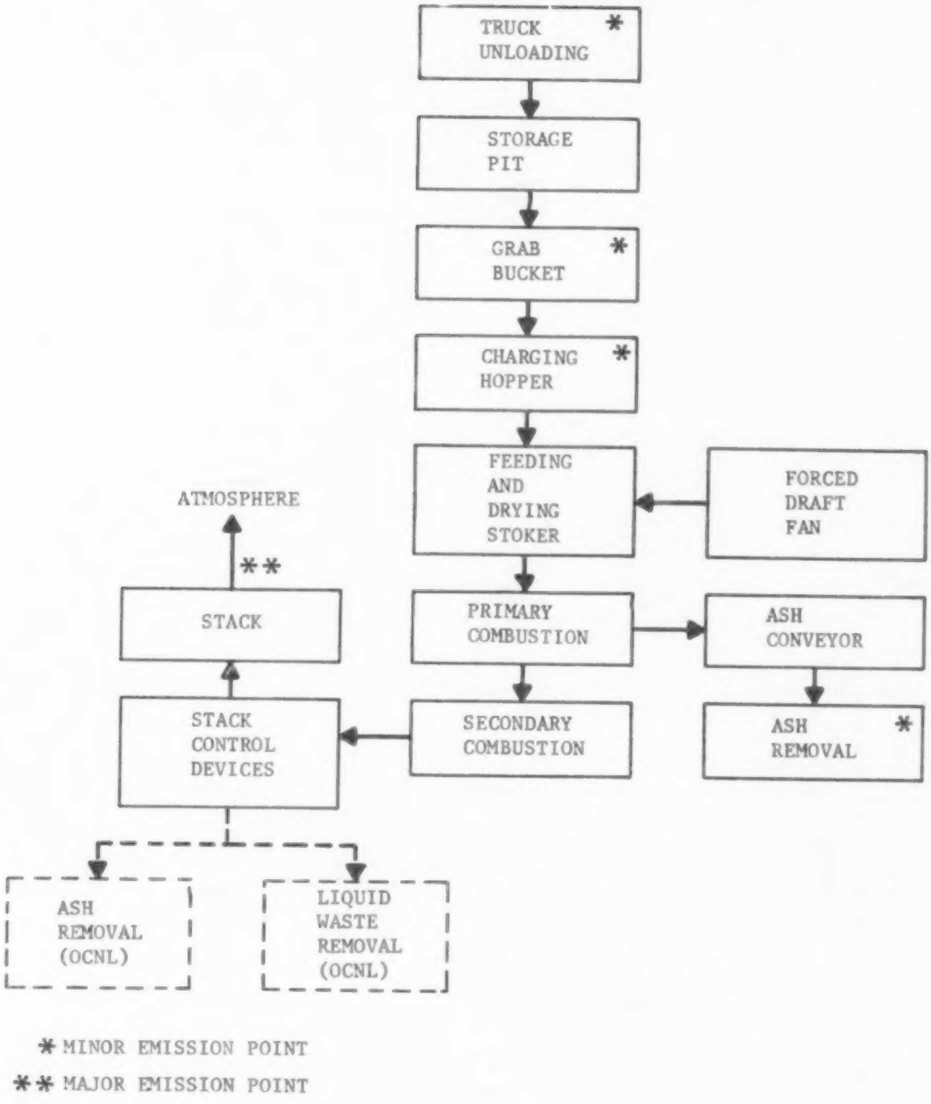

IRON ORE
*
OTHER ORES
*
COKE
*
LIMESTONE
BLAST OR ELECTRIC FURNACE
**
**
FERROALLOY INGOTS
GRINDING
*
FINISHED INGOTS

* MINOR EMISSION POINT

** MAJOR EMISSION POINT

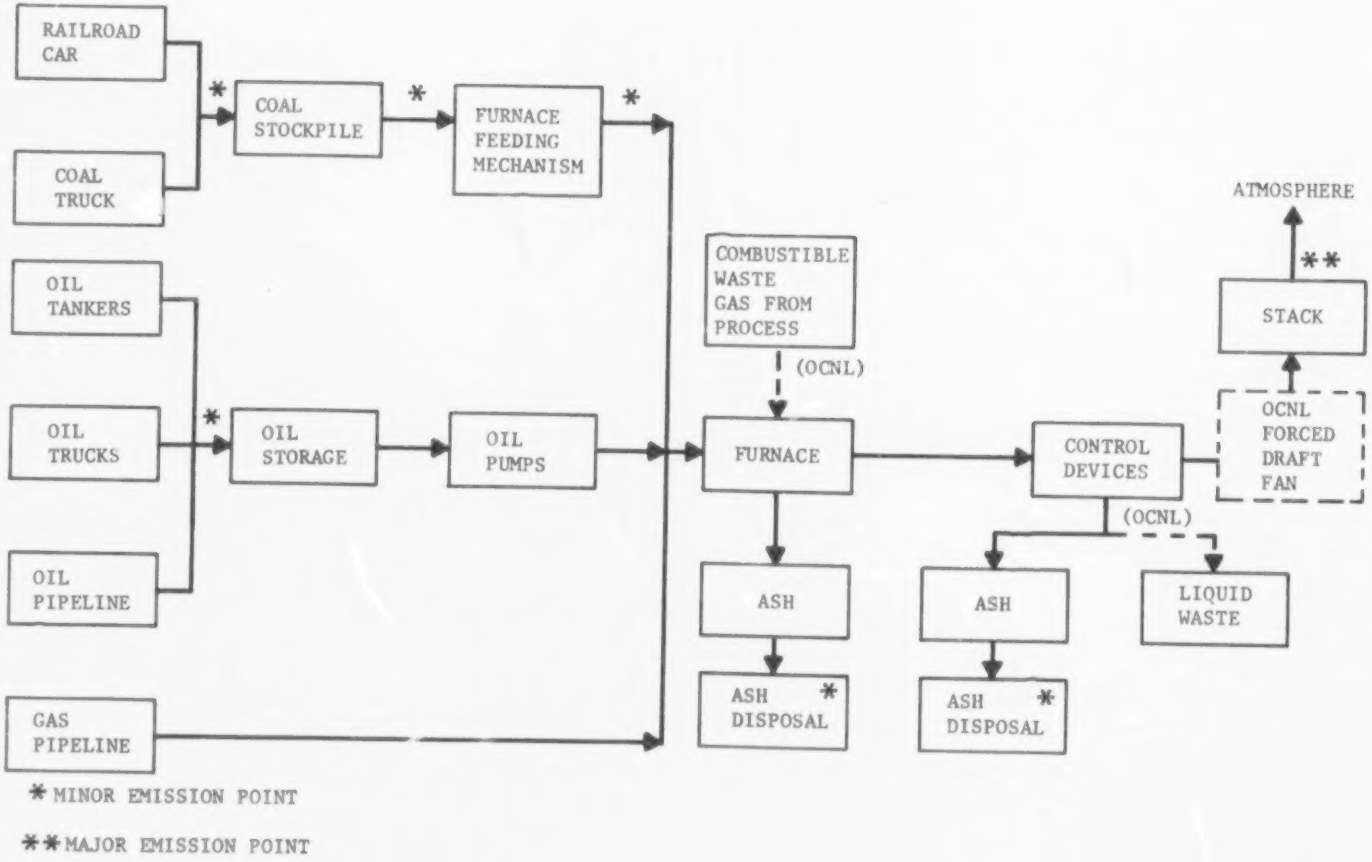
SOURCE: MITRE

BASIC OPERATIONS - FERRO-ALLOYS (INCL. SILICOMANGANESE)


TRUCK UNLOADING *
STORAGE PIT
GRAB BUCKET *
CHARGING HOPPER *
FEEDING AND DRYING STOKER
FORCED DRAFT FAN
ATMOSPHERE
**
STACK
PRIMARY COMBUSTION
ASH CONVEYOR
STACK CONTROL DEVICES
SECONDARY COMBUSTION
ASH REMOVAL *
ASH REMOVAL (OCNL)
LIQUID WASTE REMOVAL (OCNL)
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

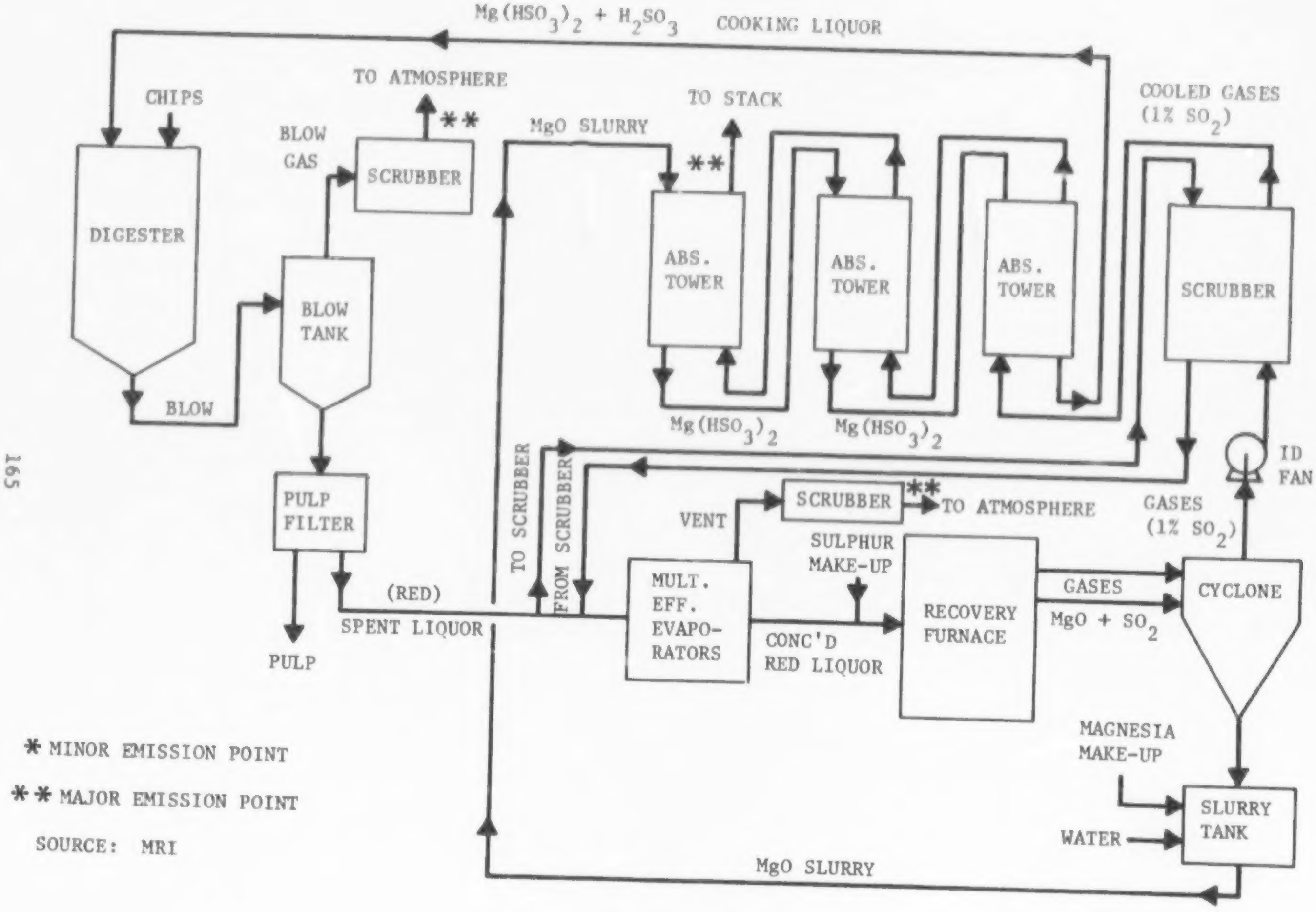
SOURCE: AIR POLLUTION
ENGINEERING
MANUAL

BASIC OPERATIONS - TYPICAL MUNICIPAL INCINERATOR


RAILROAD CAR
COAL TRUCK
COAL STOCKPILE
FURNACE FEEDING MECHANISM
OIL TANKERS
OIL TRUCKS
OIL PIPELINE
OIL STORAGE
OIL PUMPS
GAS PIPELINE
COMBUSTIBLE WASTE GAS FROM PROCESS
(OCNL)
FURNACE
ASH
ASH DISPOSAL
CONTROL DEVICES
(OCNL)
ASH
ASH DISPOSAL
LIQUID WASTE
OCNL FORCED DRAFT FAN
STACK
ATMOSPHERE
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

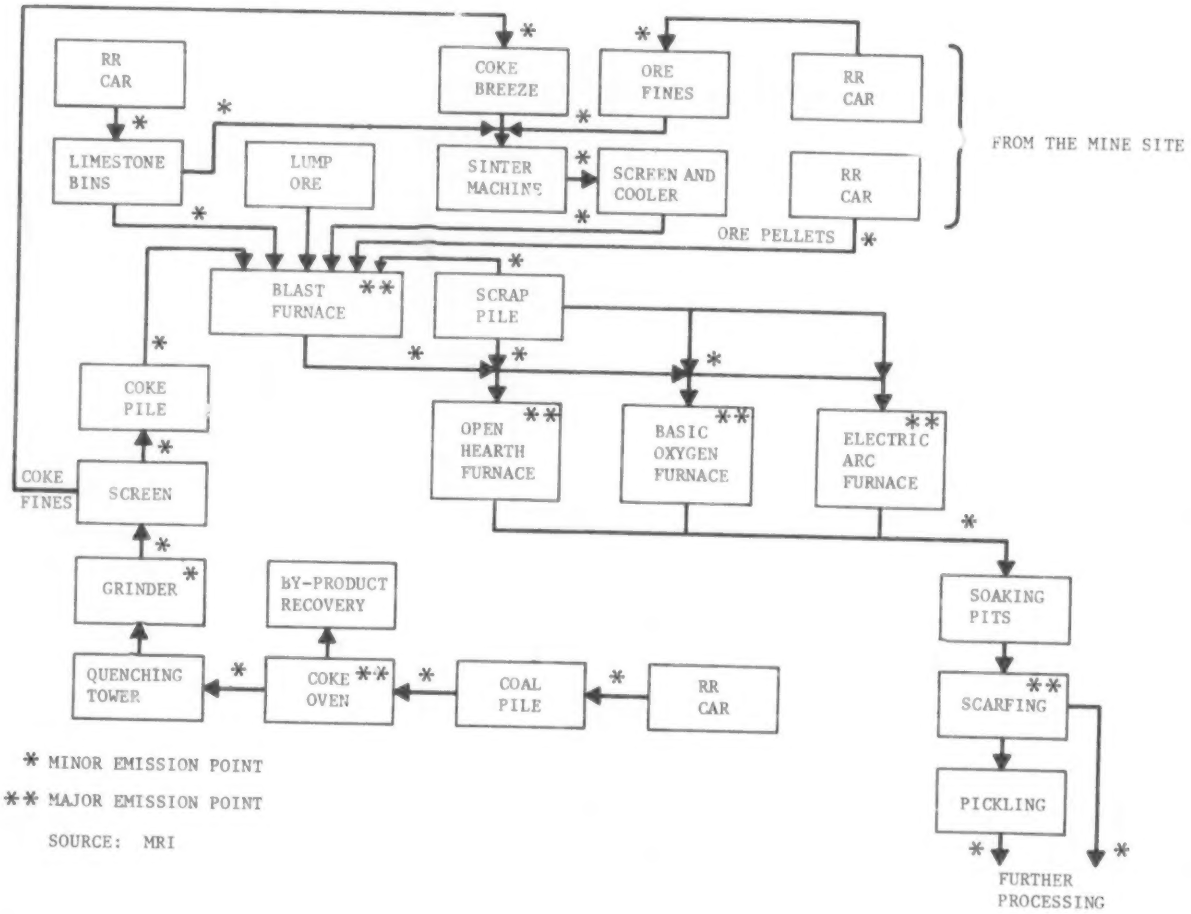
SOURCE: MITRE

BASIC OPERATIONS - INDUSTRIAL COMBUSTION

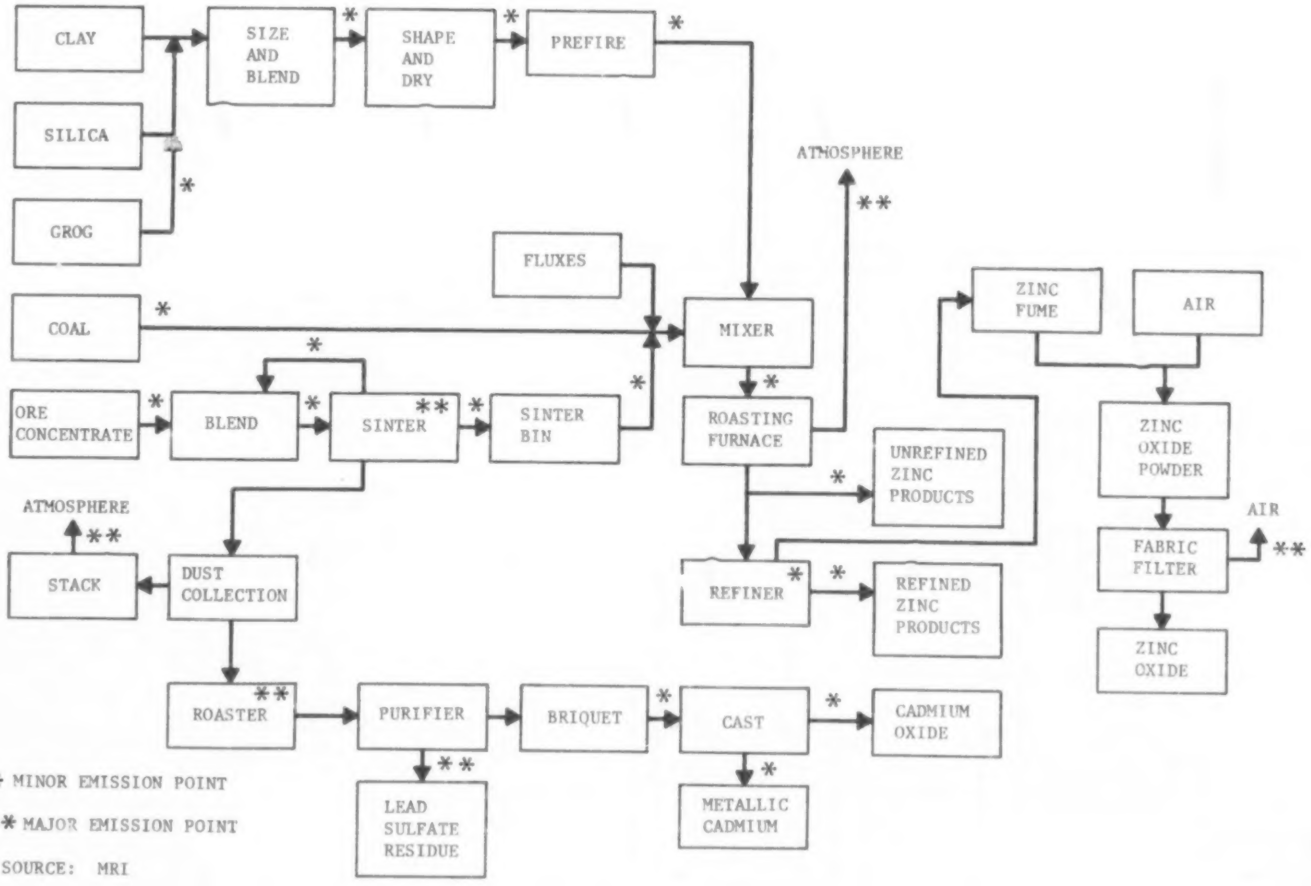

Mg(HSO$_3$)$_2$ + H$_2$SO$_3$ COOKING LIQUOR
CHIPS
DIGESTER
BLOW
BLOW GAS
BLOW TANK
SCRUBBER
TO ATMOSPHERE
**
PULP FILTER
PULP
(RED) SPENT LIQUOR
MgO SLURRY
TO STACK
**
ABS. TOWER
ABS. TOWER
ABS. TOWER
Mg(HSO$_3$)$_2$
Mg(HSO$_3$)$_2$
COOLED GASES (1% SO$_2$)
SCRUBBER
ID FAN
GASES (1% SO$_2$)
TO SCRUBBER
FROM SCRUBBER
VENT
SCRUBBER
**
TO ATMOSPHERE
SULPHUR MAKE-UP
MULT. EFF. EVAPO-RATORS
CONC'D RED LIQUOR
RECOVERY FURNACE
GASES
MgO + SO$_2$
CYCLONE
MAGNESIA MAKE-UP
WATER
SLURRY TANK
MgO SLURRY
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

SOURCE: MRI

BASIC OPERATIONS - SULFITE PULPING PROCESS, MAGNESIA BASE

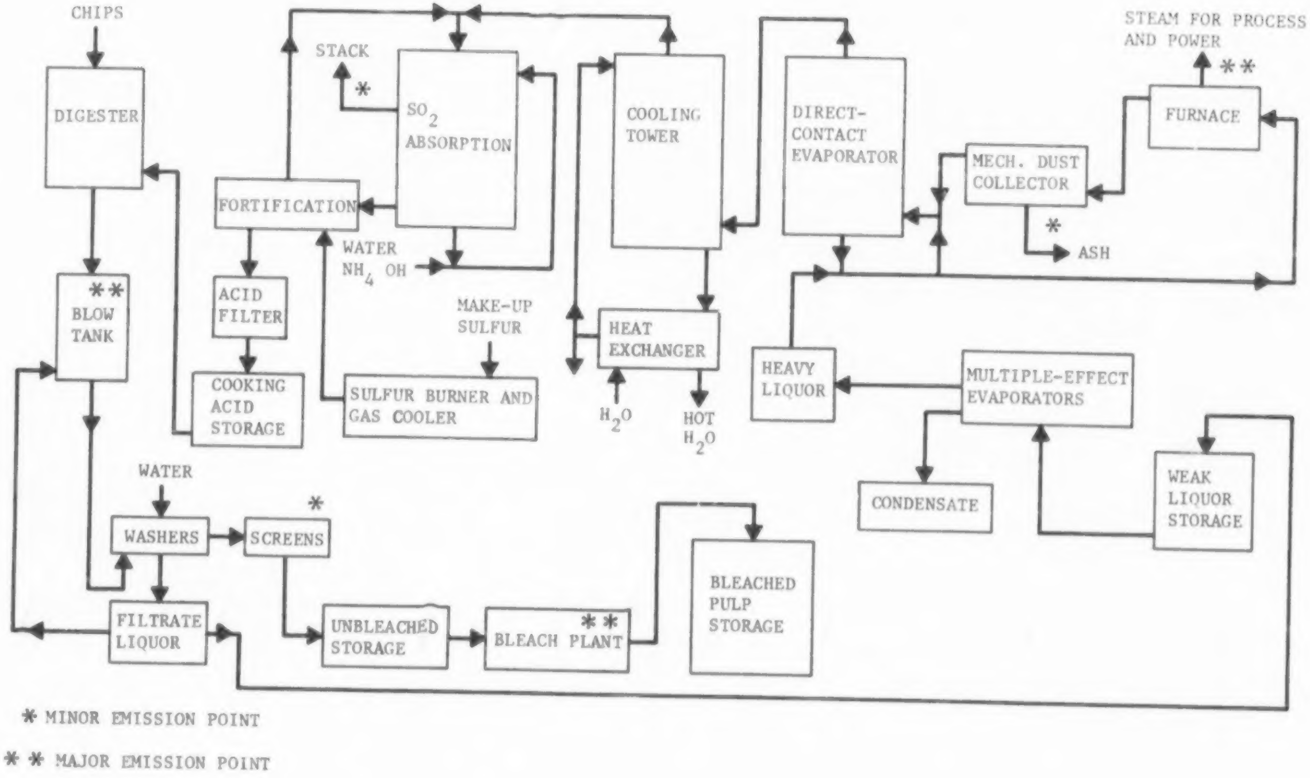

RR CAR
LIMESTONE BINS
LUMP ORE
COKE BREEZE
ORE FINES
RR CAR
SINTER MACHINE
SCREEN AND COOLER
RR CAR
FROM THE MINE SITE
ORE PELLETS
BLAST FURNACE
SCRAP PILE
COKE PILE
COKE FINES
SCREEN
GRINDER
OPEN HEARTH FURNACE
BASIC OXYGEN FURNACE
ELECTRIC ARC FURNACE
SOAKING PITS
SCARFING
PICKLING
FURTHER PROCESSING
BY-PRODUCT RECOVERY
QUENCHING TOWER
COKE OVEN
COAL PILE
RR CAR
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

SOURCE: MRI


CLAY
SILICA
GROG
COAL
ORE CONCENTRATE
SIZE AND BLEND
SHAPE AND DRY
PREFIRE
FLUXES
BLEND
SINTER
SINTER BIN
MIXER
ROASTING FURNACE
ATMOSPHERE
UNREFINED ZINC PRODUCTS
REFINER
REFINED ZINC PRODUCTS
ZINC FUME
AIR
ZINC OXIDE POWDER
FABRIC FILTER
AIR
ZINC OXIDE
ATMOSPHERE
STACK
DUST COLLECTION
ROASTER
PURIFIER
LEAD SULFATE RESIDUE
BRIQUET
CAST
METALLIC CADMIUM
CADMIUM OXIDE
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

SOURCE: MRI

BASIC OPERATIONS - PRIMARY ZINC SMELTING AND ZINC OXIDE MANUFACTURE


CHIPS
DIGESTER
** BLOW TANK
FORTIFICATION
ACID FILTER
COOKING ACID STORAGE
STACK
*
SO$_2$ ABSORPTION
WATER
NH$_4$ OH
MAKE-UP SULFUR
SULFUR BURNER AND GAS COOLER
COOLING TOWER
HEAT EXCHANGER
H$_2$O
HOT H$_2$O
DIRECT-CONTACT EVAPORATOR
HEAVY LIQUOR
MECH. DUST COLLECTOR
* ASH
STEAM FOR PROCESS AND POWER
** FURNACE
MULTIPLE-EFFECT EVAPORATORS
CONDENSATE
WEAK LIQUOR STORAGE
WATER
WASHERS
* SCREENS
FILTRATE LIQUOR
UNBLEACHED STORAGE
** BLEACH PLANT
BLEACHED PULP STORAGE
* MINOR EMISSION POINT
** MAJOR EMISSION POINT

SOURCE: MRI

BASIC OPERATIONS - SULFITE PULPING PROCESS, AMMONIA BASE